PROCEEDINGS

AND

TRANSACTIONS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

VOL. XXX.

SESSION 1915-1916.

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1916.

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PROCEEDINGS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY

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1903—1904 Rev. T. S. LEA, M.A.
1904—1905 ALFRED LEICESTER.
1905—1906 JOSEPH LOMAS, F.G.S.
1906—1907 Prof. W. A. HERDMAN, D.Sc., F.R.S.
1907—1908 W. T. HAYDON, F.L.S.
1908—1909 Prof. B. MOORE, M.A., D.Sc.
1909—1910 R. NEWSTEAD, M.Sc., F.E.S.
1910—1911 Prof. R. NEWSTEAD, M.Sc., F.R.S.
1911—1912 J. H. O'CONNELL, L.R.C.P.
1912—1913 JAMES JOHNSTONE, D.Sc.
1913—1914 C. J. MACALISTER, M.D., F.R.C.P.
1914—1915 Prof. J. W. W. STEPHENS, M.D., D.P.H.

SESSION XXX, 1915-1916.

President:

Prof. ERNEST GLYNN, M.A., M.D.

Vice-Presidents:

Prof. W. A. HERDMAN, D.Sc., F.R.S.
Prof. J. W. W. STEPHENS, M.D., D.P.H.

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C. J. MACALISTER, M.D.
Prof. MACDONALD, B.A.
WM. RIDDELL, M.A.
E. M. G. SMITH (Miss).

Representative of Students' Section:

Miss CLARK.

REPORT of the COUNCIL.

During the Session 1915-16 there have been seven ordinary meetings and one field meeting of the Society.

The communications made to the Society at the ordinary meetings have been representative of many branches of Biology, and the various exhibitions and demonstrations thereon have been of great interest.

The February Meeting was held jointly with the Students' Society, and a lecture was given by Prof. Benj. Moore, D.Sc., F.R.S., an ex-President of the Society, on "The Growth and Production of Inorganic Segregations resembling structures from living organisms."

The Library continues to make satisfactory progress, and additional important exchanges have been arranged.

The Treasurer's statement and balance-sheet are appended.

The members at present on the roll are as follows :—

Ordinary members	50
Associate members	14
Student members, including Students' Section, about	30
Total	94

SUMMARY of PROCEEDINGS at the MEETINGS.

The first meeting of the thirtieth session was held at the University, on Friday, October 15th, 1915.

The President-elect (Prof. Ernest Glynn, M.A., M.D.) took the chair in the Zoology Theatre.

1. The Report of the Council on the Session 1914-1915 (see "Proceedings," Vol. XXIX, p. viii) was submitted and adopted.
2. The Treasurer's Balance Sheet for the Session 1914-1915 (see "Proceedings," Vol. XXIX, p. xix) was submitted and approved.
3. The following Office-bearers and Council for the ensuing Session were elected :—Vice-Presidents, Prof. Herdman, D.Sc., F.R.S., and Prof. J. W. W. Stephens, M.D., D.P.H. ; Hon. Treasurer, W. J. Halls ; Hon. Librarian, May Allen, B.A. ; Hon. Secretary, Joseph A. Clubb, D.Sc. ; Council, H. C. Beasley, G. Ellison, H. B. Fantham, D.Sc., B.A., W. T. Haydon, F.L.S., J. R. Hobhouse, J. Johnstone, D.Sc., Douglas Laurie, M.A., W. S. Laverock, M.A., B.Sc., C. J. Macalister, M.D., F.R.C.P., Prof. Macdonald, B.A., W. Riddell, M.A., and E. M. G. Smith (Miss).
4. Prof. Ernest Glynn, M.A., M.D., delivered the Presidential Address on "Bacteriology and the War, with Comments on the National Neglect of Science" (see "Transactions," p. 3). A vote of thanks was carried with acclamation.

The second meeting of the thirtieth session was held at the University, on Friday, November 12th, 1915. The President in the chair.

1. Prof. Herdman submitted the Annual Report on the work of the Liverpool Marine Biology Committee, and gave an address on the "Life and Work of Edward Forbes, the Manx Naturalist" (see "Transactions," p. 53).

The third meeting of the thirtieth session was held at the University, on Friday, December 10th, 1915. The President in the chair.

1. Miss Allen, B.A., exhibited, with remarks, a copy of Prof. Edward Forbes' "Oinos eros mathesis" Club prospectus (see "Transactions," p. 95).
2. Miss Bamber, B.Sc., exhibited a series of preparations of the Liver Fluke in various clearing media.
3. Prof. Herdman, F.R.S., exhibited and described a collection which he had formed, designed to show similarity of form in certain organic and inorganic specimens.
4. Mr. Douglas Laurie, M.A., exhibited an old pattern microscope of considerable interest.

The fourth meeting of the thirtieth session was held at the University, on Friday, January 14th, 1916. The President in the chair.

1. Mr. W. S. Laverock, M.A., B.Sc., gave an interesting lecture on a recent visit to the Federated Malay States, in which a general account was given of the flora and fauna of the country. A selection of the specimens obtained was on exhibition.

The fifth meeting of the thirtieth session was held at the University, on Friday, February 18th, 1916, jointly with the Students' Society. The President of the Students' Section (Miss Clark) in the chair.

1. Prof. Benj. Moore, F.R.S., an ex-President of the Society, gave a lecture on "The Growth and Production of Inorganic Segregations resembling structures from Living Organisms."

The sixth meeting of the thirtieth session was held at the University, on Friday, March 10th, 1916. Mr. R. D. Laurie, M.A., in the chair.

1. Prof. Herdman, F.R.S., exhibited, with remarks, specimens in illustration of Prof. Moore's lecture at the February Meeting, which, owing to delay on railway, did not arrive in time.
2. J. Johnstone, D.Sc., submitted the Annual Report of the Investigations carried on during 1915 in connection with the Lancashire Sea-Fisheries Committee (see "Transactions," p. 99).

The seventh meeting of the thirtieth session was held at the University, on Friday, May 12th, 1916. The President in the chair.

1. Note on a Terebella tube new to Britain, by Arnold T. Watson, F.L.S. (communicated by Prof. Herdman) (see "Transactions," p. 161).
2. Prof. Herdman, F.R.S., gave a description of an Archaeological Find in the Isle of Man.

The eighth meeting of the thirtieth session was the Annual Field Meeting, held on Saturday, June 3rd. This was held jointly with the Liverpool Geological Society, and a very pleasant geological ramble was made, under the leadership of Mr. W. A. Whitehead, B.Sc., of the Geological Society, from Thurstaston to Heswall. At the short business meeting held after tea, on the motion of the President from the chair, Prof. J. S. Macdonald, B.A., was unanimously elected President for the ensuing session.

LIST of MEMBERS of the LIVERPOOL BIOLOGICAL SOCIETY.

SESSION 1915-1916.

A. Ordinary Members.

(Life Members are marked with an asterisk.)

ELECTED.

1908 Abram, Prof. J. Hill, 74, Rodney Street, Liverpool.

1909 *Allen, May, B.A., Hon. Librarian, University, Liverpool.

1888 Beasley, Henry C., Prince Alfred Road, Wavertree.

1913 Beattie, Prof. J. M., M.A., M.D., The University, Liverpool.

1903 Booth, jun., Chas., 30, James Street, Liverpool.

1912 Burfield, S. T., B.A., Zoology Department, University, Liverpool.

1886 Caton, R., M.D., F.R.C.P., 78, Rodney Street.

1886 Clubb, J. A., D.Sc., Hon. Secretary, Free Public Museums, Liverpool.

1910 Ellison, George, 52, Serpentine Road, Wallasey.

1902 Glynn, Dr. Ernest, President, 67, Rodney Street.

1886 Halls, W. J., Hon. Treasurer, 35, Lord Street.

1910 Hamilton, Mrs. J., 96, Huskisson Street, Liverpool.

1896 Haydon, W. T., F.L.S., 55, Grey Road, Walton.

1912 Henderson, Dr. Savile, 48, Rodney Street, Liverpool.

1886 Herdman, Prof. W. A., D.Sc., F.R.S., Vice-President, University, Liverpool.

1893 Herdman, Mrs. W. A., Croxteth Lodge, Ullet Road, Liverpool.

1912 Hobhouse, J. R., 54, Ullet Road, Liverpool.
1902 Holt, A., Dowsefield, Allerton.
1903 Holt, George, Grove House, Knutsford.
1903 Holt, Richard D., M.P., 1, India Buildings, Liverpool.
1912 Jackson, H. G., M.Sc., Zoology Department, University, Birmingham.
1898 Johnstone, James, D.Sc., University, Liverpool.
1894 Lea, Rev. T. S., D.D., The Vicarage, St. Austell, Cornwall.
1896 Laverock, W. S., M.A., B.Sc., Free Public Museums, Liverpool.
1906 Laurie, R. Douglas, M.A., University, Liverpool.
1912 Macalister, C. J., M.D., F.R.C.P., 35, Rodney Street, Liverpool.
1915 Macdonald, Prof. J. S., B.A., The University, Liverpool.
1905 Moore, Prof. B., London.
1913 Mottram, V. H., Physiological Department, University, Liverpool.
1904 Newstead, Prof. R., M.Sc., F.R.S., University, Liverpool.
1904 O'Connell, Dr. J. H., 38, Heathfield Road, Liverpool.
1913 Pallis, Mark, Tätoi, Aigburth Drive, Liverpool.
1903 Petrie, Sir Charles, 7, Devonshire Road, Liverpool.
1915 Prof. W. Ramsden, University, Liverpool.
1903 Rathbone, H. R., Oakwood, Aigburth.
1890 *Rathbone, Miss May, Backwood, Neston.
1910 Riddell, Wm., M.A., Zoology Department, University, Liverpool.
1897 Robinson, H. C., Malay States.
1908 Rock, W. H., 25, Lord Street, Liverpool.
1894 Scott, Andrew, A.L.S., Piel, Barrow-in-Furness.
1908 Share-Jones, John, F.R.C.V.S., University, Liverpool.
1895 Sherrington, Prof., M.D., F.R.S., University, Liverpool.
1886 Smith, Andrew T., 21, Croxteth Road, Liverpool.
1903 Stapledon, W. C., "Annery," Caldy, West Kirby.

1913 Stephens, Prof. J. W. W., M.D., Vice-President, University, Liverpool.

1903 Thomas, Dr. Thelwall, 84, Rodney Street, Liverpool

1905 Thompson, Edwin, 25, Sefton Drive, Liverpool.

1889 Thornely, Miss L. R., Nunclose, Grassendale.

1888 Toll, J. M., 49, Newsham Drive, Liverpool.

1891 Wiglesworth, J., M.D., F.R.C.P., Springfield House, Winscombe, Somerset.

B. Associate Members.

1915 Bamber, Miss, M.Sc., Zoology Department, The University, Liverpool.

1905 Carstairs, Miss, 39, Lilley Road, Fairfield.

1914 Cutmore, J. W., Free Public Museum, Liverpool.

1913 Hamilton, Erik, M.Sc., 96, Huskisson Street, Liverpool.

1905 Harrison, Oulton, 18, Limedale Road, Mossley Hill.

1916 Horsman, Miss Elsie, B.Sc., 17, Hereford Road, Wavertree.

1910 Kelley, Miss A. M., 10, Percy Street, Liverpool.

1912 Lyon, Miss Una, High School for Girls, Aigburth Vale, Liverpool.

1912 Parkin, Miss A. B., 3, Cairns Street, Liverpool.

1913 Smith, Miss E. M. G., 39, Parkfield Road, Liverpool

1915 Stafford, Miss C. M. P., B.Sc., 312, Hawthorne Road, Bootle.

1903 Tattersall, W., D.Sc., The Museum, Manchester.

1915 Teare, W. Rimmer, 12, Bentley Road, Birkenhead.

1910 Tozer, Miss E. N., Physiology Laboratory, University, Liverpool.

C. University Students' Section.

President: Miss Clark.

Secretary: Miss Laura Davies.

(Contains about 30 members.)

D. Honorary Members.

S.A.S., Albert I., Prince de Monaco, 10, Avenue du brocadéro, Paris.
Bornet, Dr. Edouard, Quai de la Tournelle 27, Paris.
Claus, Prof. Carl, University, Vienna.
Fritsch, Prof. Anton, Museum, Prague, Bohemia.
Haeckel, Prof. Dr. E., University, Jena.
Hanitsch, R., Ph.D., Raffles Museum, Singapore.
Solms-Laubach, Prof.-Dr., Botan. Instit., Strassburg.

THE LIVERPOOL BIOLOGICAL SOCIETY.

Dr. IN ACCOUNT WITH W. J. HALLS, HON. TREASURER. **Cr.**

1915, Oct. 1st, to Sept. 30th, 1916.	£	s.	d.
To Teas and Attendance at Meetings	3	1	1
,, Messrs. Tinling & Co.	34	16	11
,, Hon. Secretary's Expenses	2	5	0
,, Hon. Librarian's Expenses	4	8	0
,, Hon. Treasurer's Expenses	0	1	5
,, Fire Insurance—Society's Library	1	18	6
,, Balance in Bank	4	10	5
,, Cash in hand	2	1	6
	£53	2	10

1915, Oct. 1st, to Sept. 30th, 1916.	£	s.	d.
By Balance from last Account	8	9	1
,, Subscriptions :—			
Members	19	19	0
,, (Arrears)	5	5	0
Associates	3	3	0
,, (Arrears)	0	10	6
Subscriptions not advised by Bank	4	14	6
,, Sale of Volumes	6	15	0
,, Interest on Investment	4	1	10
,, Bank Interest	0	4	11
	£53	2	10

INVESTMENT :—

£125 4 % Debenture Stock (Commercial Cable Co.) at £70 .... £87 10 0

Audited and found correct,

W. T. HAYDON.

LIVERPOOL, *September 30th, 1916.*

TRANSACTIONS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

PRESIDENTIAL ADDRESS

ON

BACTERIOLOGY AND THE WAR, WITH COMMENTS ON THE NATIONAL NEGLECT OF SCIENCE.

By ERNEST GLYNN, M.A., M.D. Cantab., F.R.C.P.,
Captain R.A.M.C. (T.),
Professor of Pathology in the University of Liverpool.

[Read to the Society, October 22, 1915.]

Bacteria are usually classed as plants, but they possess at least one characteristic of animals.* They are one of the smallest, but probably not the smallest, forms of living matter. One bacterium may measure only a 1/10,000 of an inch. Bacteria may be divided into two great classes, the harmless and the harmful. The latter are injurious on account of the poisons which they contain or excrete; it is these bacteria with which we are specially concerned to-night.

Most people are probably aware that in war more soldiers die of disease, than are killed in battle or die of wounds; a very large proportion of the disease is due to harmful bacteria. "From cholera the Allies lost 10,000 men in the Crimea in 1854, and it has been stated that the Turks at one time during the last Balkan War were losing upwards of 500 men a day. Plague in 1828 took a toll of 6,000 lives in one month from the Russian army in Turkey. From all causes that army, which left Russia 100,000 strong, left 85,000 dead on Turkish soil, and had half its total strength in hospital at one time."† Dysentery caused 1,342 deaths and 38,000 cases

* The cell wall contains no cellulose but chitin.

† "Sanitation in War," P. S. Lelean. Churchill, London, 1915.

of sickness during the South African War. Enteric in 1870-1 was responsible for 73,000 cases and 6,900 deaths in the German army. From the same disease in the South African War we suffered a loss of 57,000 men infected, and over 8,000 deaths—the equivalent of two brigades.

"In our wars of the past thirty years, for every one man killed by act of the enemy we have had forty hospital admissions and lost 4·8 lives from disease; while in the South African War, sickness was responsible for a loss of 86,000 men by death and by invaliding."* Mr. Tennant recently stated in the House of Commons that, "subject to certain reservations, the total number of officers and men, including native Indian troops, leaving the Gallipoli Peninsula on account of sickness from April 25th to October 20th may be stated as 3,200 officers and 75,000 other ranks." There is no doubt that the majority of these cases of sickness were due to infections.

I will now briefly consider some of the harmful bacteria which produce diseases like typhoid, plague, cholera, etc. But you may ask what proof is there that the typhoid bacillus produces typhoid or that the diphtheria bacillus produces diphtheria, and that is a very fair question.

Let us take the particular instance of tuberculosis. How do we know that tubercle bacillus produces "consumption" of the lungs? We are certain of it for the following reasons. First, a bacillus of the characteristic appearance is always found in the lungs of patients suffering from consumption. Secondly, this bacillus can be picked out of the lungs, and grown on artificial foods or "media" in a bacteriological laboratory. Thirdly, this bacillus when it has grown, can be injected into a guinea-pig or rabbit, and the animal develops "consumption" from which it eventually dies. Fourthly, the same characteristic bacillus can be picked out from the rabbit, and when grown in media is found to

* "Sanitation in War," P. S. Lelean. Churchill, London, 1915.

resemble exactly that grown from the human being. There are other highly technical reasons.

The most important link in the whole chain of evidence is the production of the disease by inoculation of animals. For without this proof it is difficult or impossible to establish the fact that a particular germ is the cause of a particular disease. This is partly because it is unlawful to seek the truth, and try and save life by experiments upon human beings, even criminals condemned to death, though it is lawful to destroy life by blowing human beings to smithereens with shot and shell, and hacking them to pieces with swords and bayonets.

Bacteriologists have saved millions of lives by showing how certain diseases are spread, what precautions may be taken to prevent their spread, and how in some cases they may be cured. Bacteriologists will probably in the future entirely abolish many infectious diseases, but bacteriology applied to medicine and surgery is very largely based upon animal experiment. It is true they are not "vivisected" in the ordinary public acceptation of the term, there is usually no cutting, no necessity for an anaesthetic, but only the injection of cultures and other materials with hypodermic needles.

One reason why the germs of scarlet fever, measles, mumps and typhus have not been discovered, is because these diseases cannot apparently be produced in animals. Within the last five years the microbe of whooping cough is said to have been discovered, but we are not sure whether the true microbe has been found, because the cultures have no effect when injected into any of the lower animals with the exception of the monkey. Bacteriologists are not certain yet, whether the disease which the monkey develops after these injections is whooping cough or not.

Blood Poisoning.

The bacteria which produce blood poisoning are called cocci. They are found in festered fingers, sore throats, abscesses, and in wounds produced on the battle-field. Some of these cocci are present on the healthy skin. They are the bane of operating surgeons, for they frequently infect his operation wounds.

It has been found that it is much better to *prevent* the bacteria entering the wound made by a surgeon (aseptic surgery) than to allow them to enter, and then try and kill them with chemicals (antiseptic surgery).

Operative surgery in civil life is mainly "aseptic," but operative surgery in war is mainly "antiseptic" because the bacteria have already entered the wounds, and attempts are made to kill them with chemicals.

Decay of Teeth.

The decay of the teeth is very largely brought about by the action of bacteria. The public is gradually being educated to the great importance of maintaining the health of the nation by attending to the children's teeth. In the South African War 2,500 were invalided owing to defective teeth, at a cost to the country of a quarter of a million pounds.* The Warden of the Dental Hospital told me to-day that 7,000 soldiers have received dental treatment in the Liverpool area since the outbreak of war. This excludes the large numbers treated by Army dentists.

Lock-jaw or Tetanus.

The germ of Tetanus or Lock-jaw was first cultivated by a Japanese, Kitasato ; it has a characteristic appearance, being shaped like a drum-stick, the drum-stick head being

* *Lancet*, 1915, Vol. I, p. 1053.

the spore or seed of the bacillus. Owing to this spore the tetanus germ is difficult to kill by heat or disinfectants. It grows only in atmospheres devoid of oxygen. Tetanus contains a poison which is thousands of times more deadly than a grain of strychnine, so that about 1/30,000 of a grain will kill a man. The microbe resides in the soil, particularly cultivated soil which contains horse manure, for the organism is constantly present in the intestines of horses. Gelatine which is often made from the horse, sometimes contains the spores of tetanus, and fatal cases of lock-jaw have occurred in hospitals from the injection of improperly sterilized gelatine in the treatment of certain diseases. Man usually contracts tetanus from the contamination of cuts, scratches, etc., with soil. There is a popular idea that cuts on the palm of the hand between the first finger and thumb are specially liable to give lock-jaw. This is simply because such cuts are difficult to heal and are often contaminated with dirt.

Unfortunately, in the early period of the war, tetanus was very common amongst our troops in Flanders, where the soil is highly cultivated ; several deaths occurred from it at Fazakerley Hospital. Within the last few months the disease has been almost exterminated, for every wounded soldier receives as soon as possible after his injury an injection of tetanus antitoxin, and a tally is pinned on to his coat indicating the amount of serum injected. In a War Office memorandum published last July it is stated that the results of this treatment have been excellent. There have only been 36 cases of tetanus in six months among those who received a preventative dose of serum within 24 hours of being wounded. Before the treatment was instituted, numbers of cases occurred. This is one of the greatest of the recent achievements of scientific preventive medicine. If the injection of serum is delayed until the patient has developed tetanus it is usually of no value, for certain technical reasons.

Gas Gangrene.

Another terrible microbe which has been responsible for a great many deaths is the bacillus of gas gangrene. Like tetanus, it is a spore-bearing microbe which grows in an atmosphere devoid of oxygen and is also found in cultivated soil. Its poisons produce gangrene or death of a limb in a few hours, with the formation of gas; if an affected limb is placed in water, it may fizz like soda-water. This infection is exceedingly rare in ordinary civil life. No satisfactory serum has yet been discovered for it.

Mediterranean or Malta Fever.

The recent discovery of the cause of Mediterranean Fever is one of the most brilliant in the annals of medicine. The disease, which is exceedingly difficult to cure and often fatal, occurs in India, Africa, China and Europe. It was particularly common in our garrison at Malta and Gibraltar. Bruce in 1886 discovered the *Micrococcus melitensis*, and proved it to be the cause of Mediterranean Fever, partly by the experimental infection of monkeys; but the mystery as to the spread of this disease remained. In 1904, the Royal Society sent a Commission to Malta to investigate how the fever was conveyed. They proved by experiments that it was not carried by air nor by drinking water, nor by sewage, nor by contact, nor by biting insects. Then suddenly the mystery was solved. Goats' milk was the infecting agent. The Commission found that half the goats in the island were infected with the micrococcus, and 10 per cent. were actually secreting the germs in their milk. Monkeys fed with the milk of these goats almost invariably contracted the disease. The remedy was obvious. The officers and men in the garrison were prohibited under severe penalties from drinking goats' milk—and the result was marvellous.

The average number of cases of Mediterranean Fever among the Army and Navy for five years preceding 1906 was 555. In the second half of 1906 the drinking of goats' milk was prohibited, and there were 270 cases of fever. In 1907, 21; in 1908, 11; in 1909, 11; in 1910, 4; in 1911, 9; in 1912, 6. The disease is still very prevalent among the civil population who persist in drinking goats' milk, for the average number of cases during the five years preceding 1906 was 632, but they had only diminished to 318 in 1910.*

Think of the true significance of this astonishing discovery. Visitors to Malta will remember how the ubiquitous goats increase the picturesqueness of the streets. Yet these harmless-looking, common, domesticated animals, apparently in perfect health, are veritable breeding grounds of micrococci, or "germ carriers," and have been spreading Mediterranean Fever for hundreds of years—and no man knew it.

Fortunately, Malta Fever has been rare in this War amongst our troops, and is not likely to occur in epidemic form.

Spotted Fever or Cerebro-Spinal Meningitis.

This is caused by a small round microbe or coccus which is difficult to grow artificially. It produces inflammation of the coverings of the brain and spinal cord, which often terminates fatally. Isolated cases of the disease frequently occur amongst children, particularly in the spring and autumn, and occasionally it breaks out in epidemic form; thus eight years ago, 1,000 cases occurred in Glasgow, nearly half of which died.

This organism has caused the Military Authorities serious trouble during last spring and autumn, for many outbreaks of meningitis occurred, particularly in the South of England.

* Eyre, *Lancet*, 1912, Vol. I, p. 88, and private communication.

It most frequently breaks out in huts and barracks where soldiers are crowded together without sufficient ventilation. A remarkable feature of all epidemics of this disease, and one which makes it exceedingly difficult to deal with, is the fact that healthy persons who have been in contact with cases of cerebro-spinal meningitis frequently carry the germs in the back of their nose; although they may not themselves contract the disease, they may infect other more susceptible persons. Consequently, whenever a case of cerebro-spinal meningitis occurs among soldiers, all those who have been in contact with the patient are isolated and their nose examined by a bacteriologist to ascertain whether they are free from the coccus.

Last spring, there were several fatal cases of cerebro-spinal meningitis in a certain barracks at P———. I examined 195 contacts and found about four per cent. of apparently healthy men were "germ carriers." They were of course kept in quarantine and their nose treated with antiseptics till the germ was killed. The problem which the Military Authorities have had to face can be gathered by the following figures. There were 279 cases among the civil population of England and Wales in 1913, and 300 in 1914, but in the first six months of 1915 there were 2,290 among the civil population and 1,088 among the troops quartered in this country. The mortality was about sixty per cent.*

Plague.

The black death which overran Europe in the Middle Ages, and later slew 70,000 of the inhabitants of London in the reign of Charles II., almost disappeared from the civilized world during the 18th and 19th centuries, although it slumbered in the Far East. In 1894 a great outbreak occurred in Hong-

* Reece, R. J., *Journ. Roy. A. Med. Corps*, June, 1915, p. 555.

Kong, which spread to India, and eventually reached Europe, attacking the ports of Marseilles, Hamburg and Glasgow, while isolated cases occurred in Liverpool.

Research has shown that plague is due to the *Bacillus pestis*, and that the bubonic form, the common type in Europe, is entirely dependent on the infection of rats, the disease being spread from rat to rat, and from rat to man, by means of the rat flea. Fortunately the rat fleas do not usually bite man. There have been four fatal outbreaks of human plague in East Anglia within the last six years, where the disease was first introduced into Suffolk by ship rats from plague-infected countries. A few rabbits also became infected. Precautions are now taken in Liverpool, London, and elsewhere to prevent the ship rats from plague infected ports coming ashore, while city and port rats themselves are constantly being examined for plague bacilli—7,000 rats were examined in Liverpool last year.

So far as I am aware, only a few cases of plague have occurred among the belligerent armies. The disease is not likely to spread, as the last epidemic which travelled from the Far East died down a few years ago.

Cholera.

The microbe of cholera is curled rather like a comma, and it has a tail or flagellum at one extremity by which it swims. Cholera is mainly spread by infected water. Three serious epidemics occurred in Liverpool in the early part of the last century, the first being about 1832.* Behind the Liverpool Children's Infirmary there is a large playing ground. How many citizens realize that hundreds of victims of the cholera microbe are buried there? Not a tablet, not a monument marks the spot.

* It was supposed to have spread over Europe as the result of the Russo-Polic War in 1831.

"In the last Balkan War there was an outbreak of cholera behind the Chataldja lines, where it is estimated 18,000 cases occurred. It spread to the Bulgarian Army and then to those of Greece and Servia. In Europe, in 1914, cholera prevailed in Russia ; in Hungary in no fewer than 53 different centres; in Austria in 39 centres; in Germany in 10; and in Turkey in 2. In Asiatic Turkey there were two centres on the Black Sea." *

From December 27, 1914 to September 18, 1915, there have been 27,591 cases of cholera with 15,270 deaths in Austria-Hungary. The disease attained epidemic proportions in Galicia only ; civilians have been mainly infected" †

The British Government sent out experts last year to study the special types of cholera microbes in Servia in order to prepare vaccines. All British nurses going to Servia last year were obliged to be vaccinated against cholera; I myself vaccinated one nurse who had previously received vaccinations against small-pox, typhoid and tetanus. She appeared to enjoy them. If the British troops fight in the Balkans, they will be protected against cholera by means of vaccination. ‡

Dysentery.

Dysentery, an intestinal disorder quite distinct from typhoid, is a terrible disease in war. During the South African War there were 38,108 cases of dysentery. In her war with China, Japan had 155,104 cases of dysentery with 38,000 deaths. § A very large proportion of the 78,000 troops

* Simpson, *Lancet*, 1915, Vol. I, p. 741.

† *Brit. Med. Journ.*, 1915, Vol. II, p. 761.

‡ Cholera vaccine is now used extensively for our troops in the Eastern Mediterranean (June, 1916).

§ Chadwick lectures, *Lancet*, 1915, Vol. I, p. 195.

removed owing to sickness from the Gallipoli Peninsula were suffering from dysentery.

This disease is produced by at least three types of dysentery bacilli, and also by at least one, probably two or more kinds of animal parasites, an amoeba and certain flagellate organisms. The disease is spread mainly by drinking infected water, but also by flies and personal contact. The Turkish trenches are infected with it. An invalid soldier told me the other day that the flies there were so numerous that it was necessary to wave in the air every mouthful of food before eating it in order to avoid swallowing flies. As at the siege of Lucknow, there is an "infinite torment of flies."

Unfortunately, the brilliant results which have been achieved in the case of typhoid in the present campaign by protective vaccination are impossible in dysentery, partly because this disease is produced by so many different kinds of living organisms.

Enteric Fever, i.e., Typhoid and Paratyphoid Fever.

The typhoid bacillus is a rod-shaped microbe, discovered by a German in 1880. The paratyphoid bacilli, for there are at least two varieties, were discovered about twenty years later. Typhoid and paratyphoid bacilli are motile organisms swimming by means of flagella; they are distinguished from one another by certain delicate chemical tests. The former produces the well known typhoid fever which has a mortality of from five to twenty per cent., the latter produce a disease resembling mild typhoid with a mortality under five per cent. Typhoid is very common among civilians in Great Britain, and paratyphoid is rare. Typhoid has been an exceedingly deadly war disease in all campaigns except the present. Its place has been taken to a large extent by

paratyphoid, for reasons which will be alluded to subsequently.*

Enteric is spread by the germs infecting water, milk, and other food supplies such as oysters; even ice containing typhoid is dangerous. Dust and flies infected with bacilli are also responsible for the disease, particularly in war time. Investigations in Liverpool show that enteric is more common in areas where flies are abundant. Enteric is rapidly diminishing and will soon become almost extinct, simply because science has not only discovered the microbe producing the disease, but also how to prevent it from entering the human body. The Liverpool death-rate from typhoid has fallen in thirty years from 21 to 2 per hundred thousand.

Germ Carriers.

Individuals, though they have completely recovered from certain microbic or parasitic diseases, sometimes harbour the germ for months or even years, and excrete it in large numbers and so infect others. Such individuals are called germ carriers. A classical example of the "germ carrier" is that of "typhoid Mary," who was responsible for twenty-six cases of typhoid fever in seven families in America in seven years. She was finally arrested by the police, but I believe escaped, and has since spread typhoid among three other families in New York :—German families !

Punch dedicates several verses to this interesting lady, it is one of the few pieces of poetry I know :

"In U.S.A. across the brook
  There lives, unless the papers err,
A very curious Irish cook
  In whom the strangest things occur.
Beneath her outside's healthy gloze,
  Masses of microbes seethe and wallow,
And wherever Mary goes
  Infernal epidemics follow."

* Typhoid must be distinguished from typhus, the latter is a deadly War disease and is produced by an unknown living organism inoculated into the blood by the bite of body lice. No protective or curative vaccine has yet been discovered.

The detection of germ carriers is of vital importance to the Army in this war, particularly in the case of Dysentery, Enteric, and Spotted Fever. No soldier who has recovered from any of these diseases can go on active service until bacteriologists have proved by frequent examinations that he is no longer excreting the disease producing organisms.

Many thousands of examinations for "carriers" have been undertaken in the University, and the staff of the Thompson Yates, the Johnston, and the Tropical School laboratories have been considerably augmented, by the War Office, in order to cope with this work.

The difficulty of detecting carriers is sometimes so great that every soldier convalescent from enteric must be examined three times, and from dysentery three times, before rejoining for active service. Three persistent paratyphoid carriers have been discovered in the Thompson Yates laboratories, and are now in the Military Typhoid Camp where they will doubtless remain till the end of the war.

The Struggle between Man and Microbes.

I will now briefly allude to one of the most fascinating subjects in bacteriology, namely, some of the methods by which the body defends itself against the attacks of bacteria. The skin which covers the outside of the body and the mucous membrane lining the inside of the nose, throat, tonsils, lungs, etc., are its first line of defence. The lymphatic glands draining these areas form a second line. Further, the mucous membrane of the nose and throat is protected by a layer of sticky material which catches the bacteria as sticky fly-paper will catch flies.

Suppose I prick my finger with a dirty pin, i.e., one coated with harmful cocci, in other words, suppose, by means of the pin prick, the cocci break through the skin or first line of defence, what happens? The first thing that

happens is that the cocci multiply with great rapidity and invade and poison the tissues. After about twenty-four hours the injured part becomes swollen, red and painful because inflammation has set in. The redness and swelling gradually increase, and in a day or two yellow matter or pus will appear in the centre of the inflamed area. Soon the matter escapes or is let out by the surgeon, and the redness and swelling disappear. The inflammation has subsided for the cocci are dead. How has the body succeeded in winning a victory over the cocci? The victory has been won mainly by the assistance of the blood.

To understand how this takes place we must consider the structure of the blood. A single drop of human blood contains, first, about five million small round bodies, incapable of movement, which carry oxygen and are spoken of as red cells, for they give the blood its characteristic colour; and secondly, about ten thousand larger bodies, white cells which have the capacity of movement, also of absorbing and digesting bacteria—these white cells are somewhat similar to the amoebae found in stagnant water. The third constitutent is the fluid or blood plasma in which the red and white cells float. When the battle is joined, battalions of white cells and the plasma attack the bacteria, the white cells march up to them, swallow them, digest them, and so kill them. These white cells are called Phagocytes, and they will swallow twenty or thirty microbes at one meal, stuff themselves till they in turn are destroyed by the poisonous bodies of the bacteria. The phagocyte is usually compelled by an irresistible attraction to attack the bacterium: it is a case of forcible feeding. One can imagine the poor little creature who has been obliged to swallow a fatal number of bacteria say, as it dies, "you made me love and I did not want to do it." Thousands of phagocytes perish in the fray, and their dead bodies form the chief constituents of yellow matter or pus which appears after the inflammation of the finger has lasted some time.

But the body also destroys the bacteria and their poisons by the blood plasma, for it contains antibodies or substances which are antagonistic to the bacteria. The properties of these substances are wonderful, some drive the bacteria into clumps or concentration camps, from which they cannot emerge to devastate the surrounding country; some dissolve the bacteria as water dissolves sugar; some neutralize the poisons or toxins of the bacteria, in a manner somewhat resembling the neutralization of acids by alkali, these are the antitoxins. Another substance, the most remarkable of all, coats the bodies of the bacteria so that they become appetizing for the phagocytes to swallow. This substance is called opsonin. It is a sauce or butter which covers the microbe, making it attractive for the phagocyte. Further, each kind of bacterium requires a special type of opsonin or sauce, if the best results are to be obtained. The opsonin for the tubercle bacillus is different from the opsonin for the typhoid bacillus. The phagocyte is fastidious, it does not like Worcester sauce with plum pudding.

The phagocytes and blood plasma are brought to the battle-field by railway lines, namely, the arteries. But suppose the railways are not large enough to bring sufficient troops to repel the enormous number of invaders, what then? The body is able to double or treble the size of the railways by dilating the arteries so that much larger reinforcements of plasma and phagocytes are hurried to the front. Thus the inflamed part becomes red, because the arteries have enlarged to bring up more blood; the inflamed part becomes swollen, partly on account of the enormous quantities of phagocytes and plasma passing into the tissues and partly on account of the accumulation of their dead bodies in the form of pus or "matter"; the inflamed part is painful, partly because the poisons of the bacteria irritate the nerve endings. This is no fancy picture, but is capable of scientific proof.

So the battle may rage for weeks and months. The bacteria may multiply and increase in virulence, sometimes they secrete special poisons or "aggressins" which paralyse the marching power of the phagocyte, sometimes they protect themselves with special armour or "capsules" which render them impermeable to the action of the blood plasma. The phagocytes may perish in millions, and the railways leading to the battle-field become blocked with the dead, and the tissues rot away, and the body become poisoned, and die. Victory goes to the strong, that is the law of Nature.

Fortunately for us, however, the body is usually victorious in the struggle ; if it is structurally healthy it has one great asset which makes for victory, every cell, every organ does its utmost to assist in repelling the invader. *There is National Service and no Trades Union Restrictions!*

The same principles hold in the treatment and recovery of wounds received on the battle-field. Many of the clean perforations caused by the modern high velocity rifle bullet are practically sterile, but the ragged wounds made by shrapnel and high explosives are invariably infected by multitudes of bacteria, some derived from the mud and dirt with which the soldiers are often covered, others from fragments of clothing which are frequently driven into the wound.

The field dressings, which consist of antiseptic gauze soaked in a solution of iodine, are applied partly to stop the haemorrhage, partly to prevent more microbes from outside entering the wound, and partly to try and kill some of those already introduced. Later, the hospital surgeon removes as many of the bacteria as possible by washing, perhaps with antiseptics ; or allows them to escape freely by drainage.

It may appear a simple matter to kill the bacteria with antiseptics like mercury, carbolic, lysol, etc., but in practice many antiseptics do more harm than good for they destroy the phagocytes and antibodies in the plasma as well as the

bacteria. Very extensive researches are, however, being made into this question, notably under the direction of the Medical Research Committee, and a new antiseptic, Eusol, i.e., hypochlorous acid, made from bleaching powder, has recently been introduced, which seems to be the most satisfactory that has yet been devised.

Another new method, devised by Sir A. E. Wright, of treating badly-infected wounds is to wash them with solutions of harmless salts which draw out from the blood *extra quantities* of phagocytes and plasma to destroy the bacteria and their toxins.

Protection Against Microbic Diseases by Means of Vaccines and Sera.

I have already described Nature's methods of defending the body against the attacks of bacteria. Let us next consider, very briefly, how the application of these and other principles has led bacteriologists to devise new methods to assist Nature. I will mention two: first, the use of vaccines, the best known being typhoid vaccine; second, the use of sera, the best known being diphtheria antitoxin.

In order to understand the principles at work I must allude to *immunity*. Immunity means a complete or partial resistance to a particular microbe. It may be inherited by nature or subsequently acquired by training, e.g., man is by nature completely resistant to distemper, but not to plague or typhoid. On the other hand, dogs are by nature resistant to typhoid but not to distemper.

Both men and animals, however, can be *trained by Nature* to acquire considerable resistance to some microbic diseases to which they are susceptible, by a single non-fatal attack. Consequently, second attacks of typhoid or plague are rare in man, and of anthrax rare in cattle. The recovery and subsequent

resistance is partly due to the appearance in the blood of new antibodies, or antagonistic substances which damage or destroy the disease-producing microbes. I have already alluded to these. Some drive the microbes into clumps, paralysing their movements; some dissolve them; some alter them, so that the living white cells of the blood absorb and digest them; others, the well-known "antitoxins," directly counteract the poisons or toxins. These new antagonistic substances are so specialised that those produced by an attack of typhoid act only on the microbes of typhoid, and not on those of plague and other diseases. They are formed by the body as a direct result of the irritation of the disease-producing poisons, consequently the microbes unwittingly, and justly, contribute to their own annihilation.

As Nature can train men and animals to successfully resist *second* attacks of certain microbes, so man, years ago, learnt how to train animals to resist even *first* attacks of similar microbes, by inoculating them with what are called "vaccines." These vaccines are usually millions of DEAD microbes, with their poisons suspended in water. Each microbic disease requires its own special protective vaccine. A vaccine of anthrax microbes only protects against anthrax. Proper doses of any vaccine produce a very mild and greatly modified attack of the disease without risk, for the microbes are dead, and so cannot kill the patient by multiplying enormously, and thereby producing too much poison. The inoculations also cause the special antagonistic substances to appear in the blood. These facts are common knowledge amongst bacteriologists.

There is nothing miraculous or absurd in the idea of training men or animals to resist large doses of living bacteria by administration of small doses of dead ones. Many of us frequently "vaccinate" ourselves with small doses of tobacco or alcohol till we are able to resist large doses with impunity.

Most people who smoke are ill after their first pipe. An old toper can consume with impunity quantities of raw whiskey sufficient to kill a teetotaller. A morphia-maniac can take doses of morphia sufficient to kill ten ordinary individuals unaccustomed to it. Man first applied these principles to preventing anthrax, a serious disease among cattle and sheep. Over four and a half million animals were inoculated against anthrax during sixteen years in France, and the death-rate has been reduced in infected areas from 10 per cent. to 0·9 per cent.

Man next learnt that he, as well as animals, could be protected by vaccines, e.g., against plague and cholera, consequently hundreds of lives have been saved. These inoculations also produce special antagonistic substances in the blood.

Anti-Typhoid Inoculation.

In 1895, that brilliant worker, Sir A. E. Wright, extended this principle by introducing a typhoid inoculation of dead typhoid microbes. He tried it on a fairly large scale in the Boer War; about one quarter of the troops received two or only one inoculation. The chance of contracting typhoid among the protected was thereby considerably reduced, while the chance of recovery, if the disease was contracted, was greatly increased.

Since this period the efficacy of the inoculations has been greatly improved by certain important alterations in the manner of preparation and administration. They have now been used with most satisfactory results by the Italians in Tripoli, the French in Morocco and at home, the British in India, also in the Japanese Army and Navy, and in the U.S.A. Army.*

* References given in "The Principles and Practice of Antityphoid Inoculation," by E. Glynn, *Liverpool Medico-Chirurgical Journal*, July, 1915.

The appearance of new typhoid antagonistic substances in the blood after inoculation has been confirmed by independent observers in England, America, and elsewhere.

The most careful comparative tests made in the Indian Army during 1909 showed that of 10,378 inoculations 5·39 per 1,000 contracted the disease, while 8·9 per cent. of these died; whereas of 8,936 uninoculated 30·4 per 1,000 contracted the disease, and of these 16·9 per cent. died. These figures have been analysed by an expert in statistics, who found that, even "arranging them in their worst possible way," they had still a large proportion in favour of inoculation.*

Among 30,325 inoculated French troops not a single case of typhoid occurred, although among the uninoculated the case rate was 2·22 per 1,000 for home troops, and 6·34 per 1,000 for the colonial troops.*

I show you the latest available figures on the results of anti-typhoid inoculation for the British Expeditionary Force† compared with the number of cases of typhoid in some previous wars.

	Cases of Typhoid.	Deaths.	Case Mortality. Per cent.
Inoculated, 90 per cent. of Force	299*	20	6·7
Not inoculated, 10 per cent. of Force	481	100	20·79

* Of these, 142 received only one inoculation.

* References given in "The Principles and Practice of Antityphoid Inoculation," by E. Glynn, *Liverpool Medico-Chirurgical Journal*, July, 1915.

† *British Medical Journ.*, May 8, 1915, p. 819.

Objections to Inoculation.

1. Improved sanitation is said to be the sole cause of the great diminution of typhoid in recent years among many civilized nations. This is inaccurate. Although improved sanitation is partly responsible, yet it cannot possibly explain the two facts observed independently in various countries. Firstly, the protected individuals contract typhoid far less frequently than the unprotected under similar sanitary conditions. Secondly, if the protected do contract the disease, their chances of recovery are much greater than the unprotected.

2. Inoculation is injurious to health. This is also inaccurate. There is no doubt that several of those inoculated during the Boer War were severely ill for a few days afterwards, but in recent years, owing to improved methods, such illness is exceedingly rare, and is due to most unusual susceptibility. The six presidents of the Royal College of Physicians and of Surgeons in England, Scotland and Ireland, have recently stated that "with proper care inoculation has never been known to do a man harm."

Of course soldiers have died *after* vaccination, but there is no proof that they have died *because of* vaccination. The temporary illness which occasionally follows inoculation has been greatly exaggerated by those who will not, or cannot, trust the scientific men who have studied the question, or are unable to appreciate the valuable evidence or to realize the ravages in war time.

The opposition to vaccination is almost entirely the result of the propaganda of the anti-vivisectionists, who are adepts at the art of *suppressio veri* and *suggestio falsi*. Their virulent opposition is largely due to the fact that they realise how enormously bacteriology is indebted to the experimental inoculation of living animals. Their present high priest is one Walter Hadwen, M.D., L.S.A., J.P. This amusing individual

states in a recent pamphlet that "the germs of typhoid fever have never been proved to exist." How can one argue with such invincible ignorance!

Typhoid vaccine has been so successful that typhoid is no longer a disease of military importance in the British Army. It has, however, been partly replaced by the less dangerous paratyphoid, against which typhoid vaccine gives no protection. Paratyphoid is spreading, as all war diseases do, because sanitary precautions possible in peace are impossible in war. Recently (Jan., 1916), however, a new vaccine which contains paratyphoid as well as typhoid bacilli has been introduced, and I have not the slightest doubt that the number of paratyphoid cases will soon rapidly diminish.

The anti-vivisectionists have recently dared to state that the medical profession has introduced "a new title of disease under which to class inoculated men who have contracted typhoid fever, and so improve the statistics in favour of typhoid inoculation." This is a frigid lie. Paratyphoid fever was known long before typhoid vaccines were extensively used. The advance of medical knowledge in the past has frequently shown that what was first considered to be one disease is really two diseases. Time was when chicken-pox and smallpox were considered to be one disease, when measles and scarlet fever were considered to be one disease, when typhoid and typhus were considered to be one disease. The most rabid anti-vaccinationist has never yet dared to state that the medical profession invented "a new title of disease, 'chicken-pox,' in order to improve the statistics of 'smallpox.'"

We are waging the most bloody war in our history, a war upon which our national existence and the welfare of all members of this Society depend. Enteric haunts our armies like a spectre, because many ordinary sanitary precautions practised in peace are utterly impossible in war. It is always prevalent in France and Belgium, and the wet season is highly

favourable to the spread of the disease. Our brave soldiers are struggling during the autumn and winter in "one vast bog." They live in trenches, and are usually soaked with water and caked with mud, at times contaminated with enteric bacilli. Under such conditions, and because they are also constantly under fire, they cannot always drink "clean" or enteric-free water from "clean" vessels, or eat "clean" food with "clean" hands.

A soldier with enteric is useless and a hindrance to the Army; still worse, he is a positive danger to his comrades by increasing the chance of their contracting the disease. Science, especially British science, has forged a new weapon—anti-enteric inoculation—to combat a war-haunting microbe more deadly than bullets. It is our duty as patriots to encourage the use of this weapon by every means in our power, for then we shall be helping to save brave men, and so help to save our country!

Protection by Means of Sera.

The second of the new methods devised by bacteriologists to assist Nature in defeating the invasions of bacteria is the use of sera; the most notable examples being diphtheria antitoxin and tetanus antitoxin.

Diphtheria antitoxin is manufactured by training the blood of horses to resist diphtheria, with gradually increasing doses of the dead bodies of diphtheria bacilli and their poisons, that is to say, with gradually increasing doses of *diphtheria vaccines*.

After about six months' treatment the horse has become so resistant to the poisons or toxins of diphtheria that the original dose can often be increased 5,000 times without the horse experiencing the slightest inconvenience, though this dose would be sufficient to kill hundreds of unprotected horses.

Several pints of the horse's blood are now drawn off with a sterile needle and allowed to clot, and the clear fluid or serum which soon appears is found to contain diphtheria antitoxin, i.e., substances which have the properties of neutralizing the poison or toxin of diphtheria. This antitoxic serum is injected into diphtheria patients.

It must be clearly understood that the horse suffers practically no discomfort, and remains in perfect health. Indeed, if its health was not perfect, the amount of antitoxin manufactured would be greatly diminished. Tetanus antitoxin is made in the same way.

Diphtheria antitoxin is extensively used in treatment of diphtheria in every civilized country in the whole world. The treatment has saved hundreds of thousands of lives, and it is based upon scientific principles which are absolutely unassailable.

The value of diphtheria antitoxin can be proved in another way, if ten guinea-pigs are divided into two batches of five each, and one batch is inoculated with diphtheria toxin alone, and the other batch is inoculated with diphtheria toxin and diphtheria antitoxin together, the first batch will all die and the second batch will all live.

Ignorant critics say that diphtheria antitoxin is useless, because in certain great cities the total number of deaths from diphtheria has not greatly diminished. This is no reflection whatever on the value of treatment, because the crowding together of people in the cities increases the number of cases of diphtheria, consequently, even though a relatively smaller number of the infected die than formerly, yet the death-rate is not diminished to the same extent as it would be if there was no increase in the number of cases. One might just as well argue that life-boats are no use for saving sailors from shipwrecks, because the number of sailors drowned on a particular coast has not greatly diminished, since the introduction of life-boats!

Ultramicroscopic Microbes.

I have told you that the size of a microbe is about 1/10,000 part of an inch, and until recently they were believed to be the smallest living creatures. But in the last few years other living organisms, capable of producing disease, have been discovered, which are so small that the majority have never been seen even with microscopes magnifying three or four thousand times. These organisms are called ultramicroscopic organisms. They are also called "filter passers" because they are so minute that they will pass through the pores of a porcelain filter which will filter out any known bacteria, as in the purification of water.

These ultramicroscopic bodies produce foot-and-mouth disease, cattle plague, sheep-pox, hog cholera, dog distemper in animals. Their existence has been proved partly by the fact that fluids from animals suffering from foot-and-mouth disease, etc., which have been passed through a porcelain filter, still produce the particular disease when inoculated into a second and healthy animal. It is highly probable that chicken-pox, smallpox, measles, scarlet fever and yellow fever are also caused by ultramicroscopic organisms, but as it is difficult or impossible to produce such diseases in animals by inoculation, we are not certain. Some day science will see these bodies, but the time is not yet.

The Value of a Scientific Education.*

I have tried to describe some of the bloodless victories of the Science of Bacteriology, victories which are helping us to win the war. I want now to draw your attention to the value of scientific education.

* Several quotations in this section are taken from: A. The Manifesto on the Neglect of Science and the Report of the Proceedings at a Conference, Harrison & Sons, St. Martin's Lane, London (References in my paper are marked *A*); from B. Leading articles in *Nature*, between November, 1915, and May 11, 1916 (References marked *B*); and from C. Letters in *The Observer*, by Converted Classics, Shipley and H. A. Roberts and others, between January 23, 1916, and February 20, 1916 (References marked *C*).

If we look at the relative sizes of the largest and best English, American and German handbooks of Medical Bacteriology, we find that the English and American books contain under 900 small pages, the German, 5,590 large pages.* That gives a rough indication of the relative amount of work which has been done on this subject by the three nations.

If we consider the articles constantly used in a bacteriological laboratory such as microscopes, reagents and glass apparatus, we find that the best microscope costs about £100. Unfortunately, it is made in Germany. Time was when the best and most expensive microscopes were made by Ross, or Powell and Lealand in England.

The best dyes procurable are also made in Germany. Perkin, an Englishman, was largely responsible for the discovery of aniline dyes, and "during the period 1860-1865 Great Britain was the chief centre of the dyes industry, but unfortunately the necessity for continuous and careful research work was little appreciated in England" (*C*), consequently we lost the industry. At the present time we import dyes to the value of £2,250,000, of which £1,750,000 come from Germany, and the industries in which these dyes play an important or essential part are estimated at £200,000,000 per annum.†

The German dominance in the chemical world is largely due to research. "The Hoechst works employ 350 research chemists, the Badische Company about the same number, and the Baeyer Company nearly as many, in all—about 1,000 University-trained chemists, many with the highest degrees." (*C*) It has been calculated that in Germany there is one University chemist to every 50 workmen, whilst in Great Britain the ratio is certainly not higher than 1 to 500. "There were only 1,500 trained chemists in this country." (Viscount Haldane.)

* Kolle und Wassermann.

† *See* Gardner, W. M., The Brit. Coal Tar Industry. Williams & Norgate, London.

The glass apparatus used in the laboratory was also, until recently, all made in Jena, Germany. British science and industry has been seriously handicapped since the beginning of the War by the lack of proper glass apparatus. The first specimens of English glass supplied to my laboratory were pathetic failures; more recent samples have shown a great improvement. I have no doubt in time we shall be able to supply perfect imitations of the German articles, though probably at a higher price. But this is not enough, we must surpass them. To accomplish this we must remember, as King Edward said six years ago at the opening of the Congress of Applied Chemistry, "that rule of thumb is dead and rule of science has taken its place . . . , those great industries which do not keep abreast of the advance of science must surely and rapidly decline."

It is little short of a disgrace to a great nation that the best microscopes and glass apparatus, dyes, and chemicals, should be made in Germany. In my opinion the British, as a nation, are at present far less scientific than the Germans. We do not sufficiently appreciate the extraordinary importance of scientific methods and of scientific research, and of the application of results of scientific research to commerce, to industry, to war, and to every department of life. Our national attitude towards science is illustrated by the following examples:—A Liverpool would-be V.A.D., whose name I can give, while waiting for her qualifying viva-voce examination, thought a patient's temperature was taken with a barometer! A classic, whose name I can give, recently elected to a fellowship at one of the older Universities, was surprised, even interested to learn, that there are other Elements besides those of Pythagoras, viz., Earth, Air, Fire and Water! During the present war the Research Department of the Royal Woolwich Arsenal advertised for University-trained Research Chemists, at *wages of* £2 0*s*. 6*d*. *per week!* (italics mine). A

Cabinet Minister said, in the House of Commons, that his colleagues should be excused for not having prevented the exportation of fat into Germany, since it had only *recently* been discovered that glycerine, which is used for the manufacture of explosives, could be obtained from lard !

"In the whole history of the British Government there has been only one Cabinet Minister who was a trained professional man of science—the late Lord Playfair" (*A*). "Apart from a handful of University members, which includes Sir Joseph Larmor and Sir Philip Magnus as the sole representatives of the most neglected branch of human activities, there is not one scientific man in the roll of the House of Commons. In the House of Lords science is, indeed, represented by two hereditary peers, Lord Rayleigh and Lord Berkeley; but there have been no scientific men called to the peerage since the deaths of Lord Kelvin, Lord Lister, and Lord Avebury. The esteem in which science is held may be measured by the suggestion in Lord Dunraven's scheme for the reform of the House of Lords, that in the future it should consist of 400 members, whereof *two* should represent art, literature and science" (*B*).

"The Government has given a large sum for the establishment of a National Physical Laboratory, but the German Government gives three times as much, and the United States Government four times as much for their Corresponding National Institutions" (*B*). "The year before the War," says Lord Montagu of Beaulieu, "Germany spent seven millions on aviation, largely, admittedly, in experiments, in order to get certain results . . . we had great difficulty in getting £500,000 for the same purpose." The British Admiralty, he says, "up to a few days ago, was employing four or five people to try and solve a certain problem; a great American (*A*) Company is employing two hundred with the same object. A firm of German chemists acknowledges to spending approxi-

mately £1,000,000 in successfully solving the problem how to make synthetic Indigo on a commercial basis."* (*C.*)

But we are beginning to wake up and face the facts. On the 16th May, 1915, "A deputation from the Royal Society and the Chemical Society was received by the Presidents of the Boards of Trade and Education. The deputation was introduced by Sir William Crookes, President of the Royal Society, and Professor W. H. Perkin, Sir William Tilden, Professor P. Frankland, Professor W. J. Pope. Dr. M. O. Forster, who spoke in support of memorials from the two societies, indicated the steps which might be taken to improve the status and efficiency of the chemical industries and those engaging in them in the United Kingdom. The speakers said that the comparatively backward state of certain industries in this country was due to a failure to realise that modern industry *must be based on scientific research*, to the lack of the association between modern manufacturers and science, to want of scientific knowledge and appreciation of the importance of scientific work among the *public generally*, and to the lack of organization among the various chemical and allied industries. The memorials submitted by the deputation urged that the Government should give more assistance to scientific research for industrial purposes, should encourage closer relations between the manufacturers and science workers, and should establish a National Chemical Advisory Committee for these purposes."

The President of the Board of Education has recently said "the war had brought home to the Government that they were far too dependent for many processes upon the foreigner, and it was essential, if they were going to maintain their position in the world, to make better use of their scientifically-trained workers. They must increase the number of workers, and they must endeavour to secure that industry

* Badische Soda Fabrik at Ludwigshafen.

was more closely associated with scientific workers, and promote a proper system of encouragement of research workers, especially Universities. The fault in the past, no doubt, had been partly due to the remissness of the Government in failing to create careers for scientific men."

On July 1st, 1915, Lloyd George stated, in Parliament, that he was fully alive to the great importance of securing the co-operation of scientific workers throughout the country, and of utilizing, as far as practicable, the laboratories and workshops of Universities and Technical Schools.

These statements made by Cabinet Ministers are most encouraging, especially as we are chiefly governed by lawyers educated in classics, whose intellects, sometimes brilliant, are trained to regard dialectical skill, precedence, authority, and expediency, as more important than facts.*

Recently the State has appointed an Advisory Council on Scientific and Industrial Research to promote co-operation between manufacturers and scientific workers. The British Science Guild has also been founded "with the object of introducing scientific organisation and thought into the affairs of the nation." A very influential committee has been formed on "Neglect of Science," which held an important conference at Burlington House. The newly appointed Medical Research Committee is doing a most valuable work for the National Health Insurance Committee.

"Vested Interests" in Classics.

The national neglect of Science, with all its disastrous consequences in peace and especially in this war, is largely due to the dominance of the "vested interests" in classics.

* "I saw a statement the other day that the operations not only of our Army but of our Allies were being crippled, or at any rate hampered, by our failure to provide the necessary ammunition. *There is not a word of truth in that statement*" (italics mine).—Mr. Asquith at Newcastle, April 20th, 1915.

"At Cambridge, but four colleges are presided over by men of scientific training; at Oxford, not one. Of the thirty-five largest and best known public schools thirty-four have classical men as head masters. The examinations for entrance into Oxford and Cambridge, and for appointments into the Civil Service and the Army, are among the greatest determining factors in settling the kind of education given at our public schools. Natural science has been introduced as an optional subject for the Civil Service examinations, but matters are so arranged that only one-fourth of the candidates offer themselves for examination in science. It does not pay them to do so; for in Latin and Greek alone (including ancient history) they can obtain 3,200 marks, while for science the maximum is 2,400, and to obtain this total a candidate must take four distinct branches of science. For entrance into Woolwich, science has, within the last few years, been made compulsory, but for Sandhurst it still remains optional. *This College is probably the only military institution in Europe where science is not included in the curriculum*" (*A*) (italics mine).*

Sir Harry Johnson, the great explorer, points out that the Indian Civil Service examination excludes Oriental History, Oriental Zoology, Oriental Botany, Ethnology and Hygiene. The curriculum at the Foreign Office includes Ancient Greek and Latin, and Ancient Greek History, but does not include, as essential or alternatives, Russian, Turkish, Persian, Yugo-slav and Modern Greek. Arabic, however, is admitted, but it is not Modern Arabic but the Arabic of the "Arabian Nights"! Ancient Greek receives 1,200 marks, while Geography—a subject of no importance to an Empire "where the sun never sets"—receives 600 marks. How much of the Turkish muddle and the Balkan muddle is due to our idiotic and unscientific educational methods. Neither the late British Ambassador

* In the revised curriculum of Officers training for the present War, Latin and Greek, though now optional, are baited with 2,000 marks each, Geography receives 600 (Sir Harry Johnson, *Nineteenth Century*, July, 1916).

at Constantinople, nor any of the Staff spoke the language of the Country except one man :—he was recalled ! *

Classics are kept in the forefront by the "dead hand" of scholarships and foundations. The latest results of the Cambridge Big Group Scholarships—the results which show the name of the recipient, the subject and value of the scholarship—are as follows :—"48 scholarships were given for classics to the annual value of £2,380, and 39 scholarships were given for science to the annual value of £1,930." If history and mathematics are included, the figures are : Classics and History, 60 Scholarships ; Science and Mathematics, 62 Scholarships (*C*).

Another writer has analysed the apportionment of all scholarships and exhibitions at the Merchant Taylors' School, which he took as a type of public school, and he found the (*C*) total amounts offered as follows :—

Classics, including Hebrew	£7,072
Science, including Medicine	£1,983
Other subjects	£4,973

"In a recent year, according to Dr. Shipley and Mr. Roberts, in one of the greatest public schools, excellently equipped for scientific studies, less than 2 per cent. of the boys in the higher forms were giving special attention to science" (*C*). "At certain Civil Service examinations just before the War began there were 206 candidates for 78 appointments. Of those who were successful only 4 took science subjects without mathematics or classics, and 17 mathematics and science, 45 in Greek and Latin, and the remainder literary subjects, with or without mathematics" (*B*).

"In my opinion," says Professor Strong, Emeritus Professor of Latin at the Liverpool University, "the masters in our Schools should insist that science and modern languages should be regarded as equally important with classical teaching, and rewards for proficiency gained in their study should be as great."†

* Sir Edwin Pears, "Forty years in Constantinople," pp. 344, 345. Herbert Jenkins Ltd.

† *Science Progress*, April, 1916.

In spite of years of agitation on the part of scientific men, Mr. Buckmaster, late Assistant Secretary under the Board of Education, in an address to the Educational Science Section of the British Association, 1914, states, "there can be no doubt that there is less real systematic science teaching in our elementary schools than was the case twenty years ago . . . the weight of official recognition has passed from the scientific to the literary side of the secondary school." * (*B.*)

Some of those interested in the Liverpool University were greatly scandalised a few months ago because the Court finally decided to follow the example of the University of London and abolish the farce of compulsory Latin for the Matriculation of Medical Students. The University did quite right. It is a sign of the times. Soon the older Universities of Oxford and Cambridge will be compelled to abolish the farce of compulsory Greek.† It is slowly being recognised that a man can be a gentleman, who cannot write Latin verses‡ or read Greek iambics!

The present dominance of classics is a comparatively recent growth. From the Renaissance onward, "the learning of Latin was the whole aim and end of education in schools; because the language was the *living tongue of scholars*." For, as the late Mr. A. F. Leach points out in his *Schools of Mediaeval England*, "people wanted to know Latin, not to write Latin verses in imitation of Vergil, but to *speak it or to read the latest work on theology or tactics or geography.* The

* A Special Committee will shortly be appointed by the Government "To enquire into the position of Natural Science in our Educational System, especially in Universities and Secondary Schools." (Lord Crewe, at Imperial College of Science, June 30, 1916.)

† Though I received a classical education at school, I voted against Compulsory Greek at Cambridge more than twelve years ago in company with Vice-Chancellor Dale, Professor Sherrington and Professor Davies, who was at that time our Professor of Greek.

‡ "I know of boys, at schools of good repute, who spend three mornings out of the six working days making Latin verses." (Sir Harry Johnson, *Nineteenth Century*, July, 1916.)

introduction of Greek into the curriculum of schools came with the Renaissance, but was not, as is often suggested, responsible for the birth of the new learning." Greek was introduced into Winchester and Eton, New College and Magdalen, in the fifteenth century, because these schools and colleges were the advanced institutions of the day, and their scholars the leading humanists of their age, were eager for new light. "Humanism then meant the substitution of the new teaching for old, and its followers aimed at moulding the nature of man as a citizen, an active member of the State, rather than at continuing the studies of doctrines relating to the next world upon which the attention of educated mankind had been concentrated for a thousand years" (*B*).

The modern side of most schools is still regarded as a place fit only for "rotters" and "slackers," because the subjects are *not properly taught*, and because the masters too often encourage the best boys to study classics in order to win one of the numerous classical scholarships; while "stinks" is good enough for the worst! The Greeks knew better than this 2,000 years ago, for the Ephebi or undergraduates at the Periclean University used to study "Nature or Natural Science as then understood." (Dr. McCann.) (*A*.)

In my opinion, the study of natural science is a better intellectual training than the study of the dead languages and mythology of extinct races:—and it is far more useful. An average man who wants to read Greek philosophy or Roman history, how, for example, Caesar invaded Gaul and was worried by the Belgi, can read it in the King's English with far less expenditure of time, energy and money than reading it in the original. In order to study Ancient Jewish history and philosophy it is not necessary to learn Hebrew, the English translation of the Old Testament is good enough for most.

Some object to a scientific education on the ground it encourages materialism. "If we are not clever," they say, "we are at least good," "the Germans, though scientifically

trained, are wicked." They have, however, forgotten that the German character was not exactly lovable, even before they became scientific; they have forgotten 1870, and Wellington's comments more than one hundred years ago.

A boy who has a scientific education, learns that facts are of more importance than theories or opinions. He learns to have a "fluid" mind. He learns it is better to try and see, than "wait and see." He learns to "prove all things" and "hold fast that which is good." He learns to shun hypocrisy. He learns something of the greatness of Truth.

"Modern Science, as training the mind to an exact and impartial analysis of facts, is an education specially fitted to promote sound citizenship." *

If the youthful mind wants romance and inspiration he can find it in the elements of Astronomy, Physics, Chemistry, Electricity and Biology; he can find it in the brilliant achievements of scientific research, and the dogged perseverance of investigators like Darwin, Pasteur and Lister. This is, morally, better for him than studying the family life of the gods and goddesses of ancient Greece and Rome, ladies and gentlemen who were often of doubtful antecedents and of dissolute habits.

Of course, ancient Latin and Greek are useful, and must always be studied by the few; but for the great majority Natural Science and Modern not Dead languages must form in the future an essential part of a "liberal education."

Life is short, Art is long. The capacity of the human mind is limited. The intellectual struggle for life among nations is becoming fiercer. We must discard old methods. We must become more utilitarian. We must march with the times, if we wish our Empire to survive in the "struggle for existence."

When peace is declared, "when the war-drum throbs no longer and the battle-flags are furled," when this country is recovering from the loss it has sustained in men, money and

* Karl Pearson, "Grammar of Science," p. 11. Walter Scott.

material, we shall have to face problems, many of which, being biological, should interest the members of this Society. We shall have, for example, to consider the application of biological knowledge to the problems of Capital and Labour. If the Trades Union leaders had the slightest conception of the principles of Biology, of the laws of Growth and Degeneration, they would not tolerate the infamous habit of discouraging, even penalising, a worker for doing his *best* at his "job," for making the *best* of his "talents" be they one or ten.* It is a habit which is biologically immoral! Inexorable Nature will inevitably damn the nation which continues to practise it.

We shall have to consider how biological knowledge regarding the laws of heredity can best be applied to discourage the marriage of the unfit, and the elimination of the "born tireds," the insane, the habitual criminals and habitual drunkards. We shall also have to re-consider how biological knowledge regarding the influence of environment upon physique, upon character, and upon intellect can best be applied to the education of the Nation's children.

We shall have to bring scientific methods, scientific knowledge and scientific research into every department of life.

> "For now the day is unto them that know,
> And not henceforth she stumbles on the prize;
> And yonder march the nations full of eyes."
>
> (*William Watson.*)

* "Loyal men have been terrorised into restricting output, as in the case of an Enfield rifleman who was able to earn 1s. 6d. per hour, but was not allowed to rise above 1s. Another man was fined by his Friendly Society for working too quickly; another was terrorised by the Arsenal foreman for doing "too much"; a whole shop was set on to mock a clever fellow making 4·5 guns in the Coventry Ordnance Works because he finished a job in 8½ hours that ought to have taken 31½ hours. Belgian workmen in England have been warned against breaking Trades Union customs by working too hard." (Leading Article, *Liverpool Daily Post*, Lloyd George's Bristol Speech, September 10, 1915.)

In spite of the Munitions Act, Sir William Beardmore, at the Annual Meeting of Iron and Steel Institute, made the following statement:—"The production of shells at Park Head Forge Projectile Factory by girls was in all cases more than double that of thoroughly-trained mechanics—members of the *Trades Unions*—working the same machines under the same conditions." (*Times*, May 5, 1916.)

THE MARINE BIOLOGICAL STATION AT PORT ERIN

BEING THE

TWENTY-NINTH ANNUAL REPORT

OF THE

LIVERPOOL MARINE BIOLOGY COMMITTEE.

The prolongation of the European War renders the words with which I began the last Report still appropriate: "In this very exceptional year, when many concerns not directly connected with the necessities of existence or the conduct of a great war must suffer more or less, it is not surprising to find that we have a less successful year than usual to record at our Biological Station. The thoughts and energies of most of us have been diverted to other channels; and although it is right that in the interests of others we should endeavour to keep all our affairs, so far as may be possible, running normally, still until more important and pressing matters are settled it is well that no unnecessary time, labour and expense should be devoted to what is not essential at the moment. Consequently the Committee and our other supporters and readers will, I am sure, understand and approve if the Report this year takes a shorter form than usual, and deals with little beyond the record of routine work carried out at the Port Erin Biological Station and elsewhere in the L.M.B.C. District."

The "Station Record" and the "Curator's Report" which follow show that during the Easter vacation and the Spring months, when both students and senior workers frequent our marine laboratory more than at any other time of the year, the numbers were greatly reduced. Last year we recorded ninety researchers and students occupying work-places in the laboratory; this year we had only fifteen. The effect of the war upon the number of visitors to the Aquarium was most striking. Port Erin was, comparatively speaking,

deserted during the Summer, and our total number of visitors for the year is now a little over 1,500, in place of the 15,000 we had in a recent season. The number of " Guides " to the Aquarium sold to visitors is only 88, compared with about 1,000 in a normal year.

It may be useful to students and others proposing to work at Port Erin that the ground plan of the buildings showing the laboratory and other accommodation should be inserted here (see fig. 1, p. 41).

In regard to the educational work in the laboratories, the usual Easter vacation course in Marine Biology was carried on during April with greatly reduced numbers. Although no members of the staffs of the Zoology and Botany departments of the University of Liverpool were able, for various reasons, to visit Port Erin this year, a group of nine senior students of the University worked with great enthusiasm for about three weeks. The only other Universities represented were Cambridge (including Newnham), and the University of Manchester.

Work out at sea was wholly prevented, by Admiralty regulations, but collecting expeditions as usual, along the shore at low tide, were arranged in the Easter vacation. During the remainder of the year the Curator and his staff made periodic collections from time to time as occasion offered, and plankton samples were taken across Port Erin Bay with regularity twice in each week throughout the year.

As on previous occasions, the statistics as to the occupation of the " Tables " during the year will first be given, then will follow the " Curator's Report," and after that, as this year is the one-hundredth anniversary of the birth of Professor Edward Forbes, I have considered it appropriate to give a brief account of the work of that celebrated Manxman (see p. 53) for the information of our students and other workers at the laboratory.

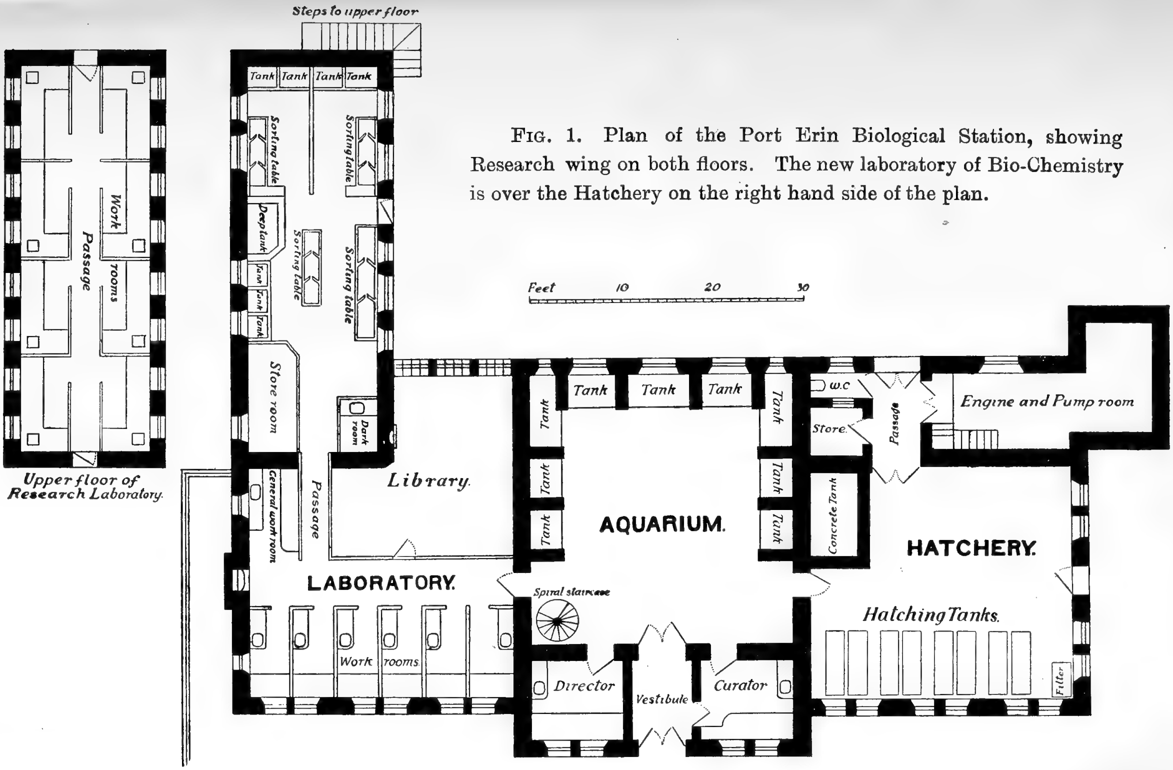


FIG. 1. Plan of the Port Erin Biological Station, showing Research wing on both floors. The new laboratory of Bio-Chemistry is over the Hatchery on the right hand side of the plan.

The Station Record.

Only fifteen workers occupied our laboratories during the past year. This number presents a remarkable contrast to those recorded in the Annual Reports of the past few years; and it is necessary to refer back to the Fourteenth Annual Report (for the year 1899) to find a record of so small an attendance of workers. But though the number of students was small, and the facilities for the collection of material were somewhat curtailed by the prevailing war conditions, it is gratifying to record that there was no lack of the enthusiasm which has always prevailed amongst our workers, especially during the Easter vacation; and, apart from the shrinkage in numbers, and having regard to the unusual conditions which the war has imposed, the work of the year may be justly regarded with satisfaction.

List of Workers.

Dec. 28*th*, 1914, *to Jan.* 11*th*, 1915.	Professor Herdman.—Official.
March 29*th to April* 9*th*.	Miss R. Holden.—Marine Algæ.
„	Miss M. Jepps.—General.
April 6*th to* 20*th*.	Miss L. Davies.—General.
„	Miss G. Andrew.—General.
April 6*th to* 26*th*.	Miss C. Whittaker.—General.
„	Miss M. Tesh.—General.
„	Miss N. Lodge.—General.
„	Miss J. Price.—General.
„	Miss J. Curwen.—General.
„	Miss J. Lord.—General.
„	Miss E. Catlow.—General.
July 30*th to Aug.* 14*th*.	Miss R. C. Bamber.—Tubularia.
Aug. 23*rd to Sept.* 2*nd*.	Mr. G. M. Graham.—General.
Aug. 24*th to Sept.* 2*nd*.	Mr. A. E. Kidd.—Collecting.

The "Tables"* in the Laboratory were occupied as follows:—

* Since the new research wing has been added several distinct apartments are generally available for the accommodation of the investigators assigned to any one of the University "Tables."

Liverpool University Table :—

Professor Herdman.
Miss L. Davies.
Miss G. Andrew.
Miss C. Whittaker.
Miss M. Tesh.
Miss N. Lodge.
Miss J. Price.
Miss J. Curwen.
Miss J. Lord.
Miss E. Catlow.
Mr. A. E. Kidd.
Miss R. C. Bamber.

Liverpool Marine Biology Committee Tables :—

Miss R. Holden.
Miss M. Jepps.

Manchester University Table :—

Mr. G. M. Graham.

The other Tables remained unoccupied.

Curator's Report.

Mr. Chadwick reports to me as follows on the various departments of the work :—

The Fish Hatchery.

"Plaice hatching operations were begun nearly three weeks later this year than last. The stock of spawners consisted of 70 fish of the previous year's stock, and 79 which were collected by the Assistant Curator during two trips in the steam-trawler 'Lady Loch,' in October, 1914. To these were added two plaice from one of the Aquarium tanks, making a total of 151 fish. The first batch of fertilised eggs, numbering 12,600, were placed in the hatching boxes on February 24th, but it was not until March 9th that more than 100,000 eggs were collected in one day; and the daily numbers continued to be comparatively small until March 17th, when there was a marked rise. Thereafter, considering the comparatively small number of spawners, the collections maintained a good standard, exceeding 400,000 eggs on two occasions, and half a million on one. On April 30th the number of eggs collected again fell below 100,000, and the spawning season closed on May 5th with a total of 6,664,250 eggs.

"The Hatchery Record, giving the number of eggs

collected, and of larval fish set free on the various days, is as follows :—

Eggs collected.		Date.	Larvae set free.		Date.
37,800	...	Feb. 24 to March 2	24,150	...	March 22
79,800	...	March 5	65,100	...	„ 25
279,300	...	„ 8 to 10	249,480	...	„ 29
350,700	...	„ 11 to 13	298,200	...	April 1
854,600	...	„ 15 to 20	672,000	...	„ 9
870,450	...	„ 22 to 24	647,850	...	„ 12
245,700	...	„ 26 and 27	354,900	...	„ 14
577,500	...	„ 29 and 30	381,100	...	„ 16
980,700	...	„ 31 to April 3	832,650	...	„ 21
231,000	...	April 5 and 7	359,950	...	„ 22
472,500	...	„ 10	371,650	...	„ 26
336,000	...	„ 12 and 13	286,650	...	„ 29
273,000	...	„ 14	211,050	...	„ 30
417,900	...	„ 17 and 19	362,250	...	May 1
514,500	...	„ 21 and 23	227,850	...	„ 6
142,800	...	„ 26 and 30	280,350	...	„ 10
6,664,250	Total eggs.		5,625,180	Total larvae.	

“ In one of the Aquarium tanks we now have on view about a score of plaice hatched during the season of 1913 and since reared in one of the spawning ponds. The largest are 8 inches long. Probably half the number have more or less pigmentation on the normally unpigmented or ‘ eyeless ’ side. In one case the pigmentation covers the whole of the ‘ eyeless ’ side except the head. In several others rather more than the posterior half of the ‘ eyeless ’ side is uniformly pigmented, and in others the pigmentation occurs in groups of spots. In most cases the pigmentation is of exactly the same depth as that of the ‘ ocular ’ side, but in one of the largest fish it is distinctly paler. We have always noticed the prevalence of pigment on the ‘ eyeless ’ side of young plaice reared in our ponds, and it is evident that factors other than light contribute to its formation.

Lobster Culture.

"When, at the close of the plaice hatching season, the spawning ponds were drained and cleaned, a total number of 46 lobsters, all purchased during the season of 1914, were found therein. Twenty-six of them were in the lobster pond, the remaining 20 having escaped thence into the larger plaice pond during the plaice hatching season. Of the 26 found in the lobster pond 3 were males and 23 females. Eight of the latter bore eggs in an unripe and faulty condition; 13 had borne eggs but were practically stripped, and the remaining 2 showed no trace of eggs. The 8 which bore eggs were returned to the lobster pond; and to them were added on various dates from June 19th to August 5th thirteen berried lobsters bearing nearly ripe eggs, all purchased from local fishermen, making a total of 21. Larvae appeared in small numbers in the pond early in June, and the first lobsterlings were set free on June 24th, a date earlier than in any previous year. The total number of larvae taken from the pond during the season was 17,490. Of these, 9,800 were set free in the first stage. The Assistant Curator undertook the larger share of the work of rearing the larvae which were placed in the hatching boxes for that purpose; and of 4,235 larvae of which he had charge, 193 reached the lobsterling stage. The Curator took charge of 3,455 larvae and reared 37 lobsterlings. Mr. Cregeen fed his larvae upon minced liver of the edible and shore crabs, supplemented almost daily with living plankton taken with a coarse tow-net. The Curator fed his larvae upon the finely-minced posterior adductor muscle of the edible mussel (*Mytilus edulis*), of which they partook freely, but which, judging from the smaller percentage of larvae reared, is probably less nutritious than plankton.

The Aquarium.

"The number of visitors to the Aquarium—1,531—is by far the smallest yet recorded; but, according to the passenger traffic returns of the Isle of Man Steam Packet Co., it represents 10 per cent. of the total number of visitors carried to the Island during the past season. The loss by resignation of the junior assistant early in the season, and the large demands made by the lobster culture and trammel-net fishing upon the time of the Staff, made the care of the tanks a more than ordinarily difficult matter; but everything possible was done to maintain them in an attractive condition, and the visitors, few in numbers, were as appreciative as ever.

General.

"The Curator's hope of being at liberty to devote more of his time to outdoor faunistic work and the care and improvement of the museum collection has not been realised. The discovery of *Rhizogeton fusiformis,* Agassiz, an interesting addition to the Hydroid fauna of the Isle of Man, was a result of one of his infrequent visits to the shore at Port St. Mary; and it shows once more that much remains to be done to make our knowledge of the local marine fauna complete.

"On August 12th a male porpoise was captured in our trammel-net and was brought ashore by Mr. Cregeen. Its measurements were—length, 4 feet 10 inches; girth just behind the flippers, 3 feet 4 inches.

"The official plankton gatherings have been taken twice weekly, with almost unfailing regularity, by the Assistant Curator."

(Signed) H. C. Chadwick.

Report of the Edward Forbes Exhibitioner.

An "Edward Forbes Exhibition" has been founded* this year, at the University of Liverpool, in commemoration of the pioneer marine biological work done in this district by the celebrated Manx Naturalist, who was born just a hundred years ago. The object of the Exhibition is to enable some post-graduate student of the University to proceed to the Port Erin Biological Station for the purpose of carrying on some piece of biological research, more or less in continuation of some line of work opened up by Forbes, or an investigation which has grown out of such work.

The first Edward Forbes Exhibitioner, elected for the year 1915, is Ruth Culshaw Bamber, M.Sc., who spent a couple of weeks at Port Erin in the summer working at the structure and life-history of the large Hydroid Zoophyte, *Tubularia indivisa*, with the view of eventually preparing an L.M.B.C. Memoir on the subject. Miss Bamber reports as follows on her work at Port Erin :—

"I went to Port Erin on July 29th, and returned to Liverpool on August 14th. During my stay I spent most of the time in examining living specimens of *Tubularia*, and in fixing and preserving material to bring back to Liverpool for sectioning during the winter.

"Only two species of *Tubularia* were found :—*T. indivisa*, which grows in abundance around the 'Sugar Loaf Rock,' near Port St. Mary, and *T. larynx*, which grows in a small colony on the Sker Rock, off Bradda Head at Port Erin. All the specimens of *T. indivisa* were found to be in a newly decapitated condition, there being no mature hydranths in any of the colonies examined; but there was every possible stage in the regeneration of the hydranth. The colonies of

* The Regulations in regard to the Exhibition will be found in Appendix B at the end of this Report.

T. larynx on the other hand had fully mature hydranths, evidently shedding their larvae ; for I found many newly fixed actinulae, and many well developed larvae still in the gonophores ; but I was unable to find any free larvae in the plankton of the bay. This was probably due to the fact that there are very strong currents around the Sker Rock* which would carry the larvae rapidly away.

"*Tubularia* can be obtained only at very low tides, and lives only for a few days in the tanks at the Biological Station; so for nearly a week in the middle of my visit I had no living material. During this time I examined in the laboratory about half a dozen different series of sections through *Tubularia*, belonging to Mr. Chadwick at the Biological Station, and found many interesting problems which I shall attempt to solve during this winter with the aid of some long series of sections of my own which are now being made.

"I gladly acknowledge the help afforded me by the Biological Station, both in connection with the collection of the necessary material, and also in the subsequent work upon it. I hope to complete the investigation in the University Laboratory of Zoology, at Liverpool."

(Signed) RUTH C. BAMBER.

L.M.B.C. MEMOIRS.

Since our last report was published, Memoir XXIII., on the Oligochaet worm TUBIFEX, by Dr. Gertrude Dixon, has been issued to the public. Miss E. L. Gleave, M.Sc., has nearly completed her Memoir on DORIS, the Sea-lemon ; Mr. Burfield, who was writing the Memoir on SAGITTA, has joined the Army ; and still other Memoirs are in preparation.

* See Fig. 2, on page 52.

The following shows a list of the Memoirs already published or arranged for :

I. Ascidia, W. A. Herdman, 60 pp., 5 Pls.
II. Cardium, J. Johnstone, 92 pp., 7 Pls.
III. Echinus, H. C. Chadwick, 36 pp., 5 Pls.
IV. Codium, R. J. H. Gibson and H. Auld, 3 Pls.
V. Alcyonium, S. J. Hickson, 30 pp., 3 Pls.
VI. Lepeophtheirus and Lernæa, A. Scott, 5 Pls.
VII. Lineus, R. C. Punnett, 40 pp., 4 Pls.
VIII. Plaice, F. J. Cole and J. Johnstone, 11 Pls.
IX. Chondrus, O. V. Darbishire, 50 pp., 7 Pls.
X. Patella, J. R. A. Davis and H. J. Fleure, 4 Pls.
XI. Arenicola, J. H. Ashworth, 126 pp., 8 Pls.
XII. Gammarus, M. Cussans, 55 pp., 4 Pls.
XIII. Anurida, A. D. Imms, 107 pp., 8 Pls.
XIV. Ligia, C. G. Hewitt, 45 pp., 4 Pls.
XV. Antedon, H. C. Chadwick, 55 pp., 7 Pls.
XVI. Cancer, J. Pearson, 217 pp., 13 Pls.
XVII. Pecten, W. J. Dakin, 144 pp., 9 Pls.
XVIII. Eledone, A. Isgrove, 113 pp., 10 Pls.
XIX. Polychaet Larvæ, F. H. Gravely, 87 pp., 4 Pls.
XX. Buccinum, W. J. Dakin, 123 pp., 8 Pls.
XXI. Eupagurus, H. G. Jackson, 88 pp., 6 Pls.
XXII. Echinoderm Larvæ, H. C. Chadwick, 40 pp., 9 Pls.
XXIII. Tubifex, G. C. Dixon, 100 pp., 7 Pls.
Doris, E. L. Gleave.
Tubularia, R. C. Bamber.
Aplysia, N. B. Eales.
Himanthalia, H. S. Holden.
Sagitta, S. T. Burfield.
Actinia, J. A. Clubb.
Zostera, R. Robbins.
Halichondria and Sycon, A. Dendy.

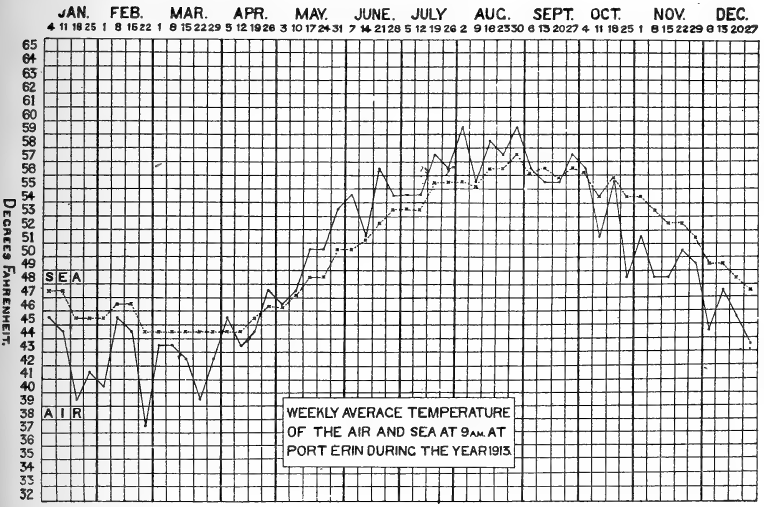
Oyster, W. A. Herdman and J. T. Jenkins.
Sabellaria, A. T. Watson.
Ostracod (Cythere), A. Scott.
Asterias, H. C. Chadwick.
Pycnogonum, J. E. Hamilton.
Botrylloides, W. A. Herdman.

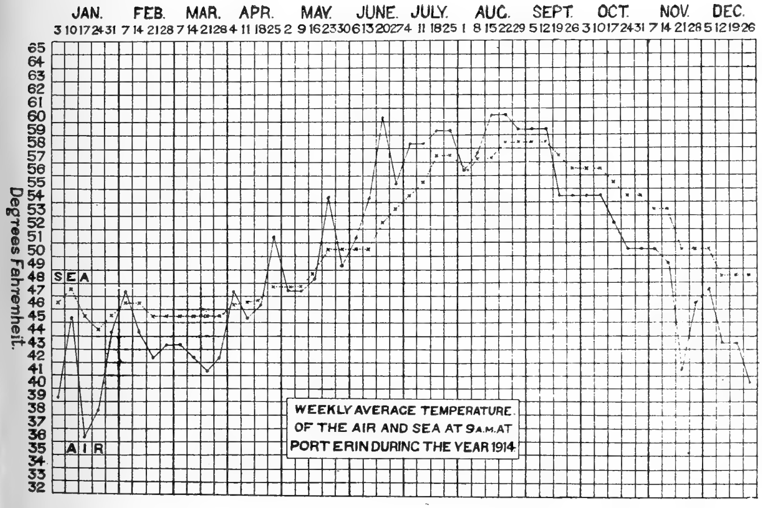
In addition to these, it is hoped that other Memoirs will be arranged for, on suitable types, such as *Pontobdella*, a Cestode, a Nematode, and a Cirripede.

As the result of a slight fire in the Zoology Department of the University, a portion of the stock of L.M.B.C. Memoirs has been partially destroyed. There are a certain number of damaged copies of some of the Memoirs which are stained or singed externally, but are still quite usable, and are suitable for laboratory work. The Committee has decided to offer these at prices ranging according to the condition from one-half to one-fourth of the published prices, as follows:—Memoir I., Ascidia, 6d. to 9d.; VI., Lepeophtheirus and Lernæa, 6d. to 1s.; VII., Lineus, 6d. to 1s.; XIII., Anurida, 1s. to 2s.; XIV., Ligia, 6d. to 1s.; XV., Antedon, 6d. to 1s. 3d.

Orders for these damaged copies should be sent to Professor Herdman, the University, Liverpool. New copies of any of the Memoirs should be ordered from Williams & Norgate.

The diagram of sea and air temperatures for 1915, compiled by Mr. Chadwick from his daily records, is not yet completed; but those for the two preceding years, 1913 and 1914, are inserted here to show the general similarity of the two curves along with a few points of divergence, and to demonstrate again the manner in which the temperature of the sea lags behind that of the air in both winter and summer. The annexed charts show clearly the points of agreement and of difference between the two years.


JAN. FEB. MAR. APR. MAY. JUNE. JULY AUG. SEPT. OCT. NOV. DEC.
Degrees Fahrenheit.
SEA
AIR
WEEKLY AVERAGE TEMPERATURE OF THE AIR AND SEA AT 9 A.M. AT PORT ERIN DURING THE YEAR 1913.


JAN. FEB. MAR. APR. MAY. JUNE. JULY. AUG. SEPT. OCT. NOV. DEC.
Degrees Fahrenheit.
SEA
AIR
WEEKLY AVERAGE TEMPERATURE OF THE AIR AND SEA AT 9 A.M. AT PORT ERIN DURING THE YEAR 1914.

Appended to this Report are :—

(A) An Address on the Life and Work of Edward Forbes, delivered to the Biological Society, by Prof. Herdman, on November 12th, 1915 ;

(B) The usual Statement as to the constitution of the L.M.B.C., and the Laboratory Regulations—with Memoranda for the use of students, and the Regulations in regard to the "Edward Forbes Exhibiton" at The University of Liverpool ;

(C) The Hon. Treasurer's Report, List of Subscribers, and Balance Sheet for the year.

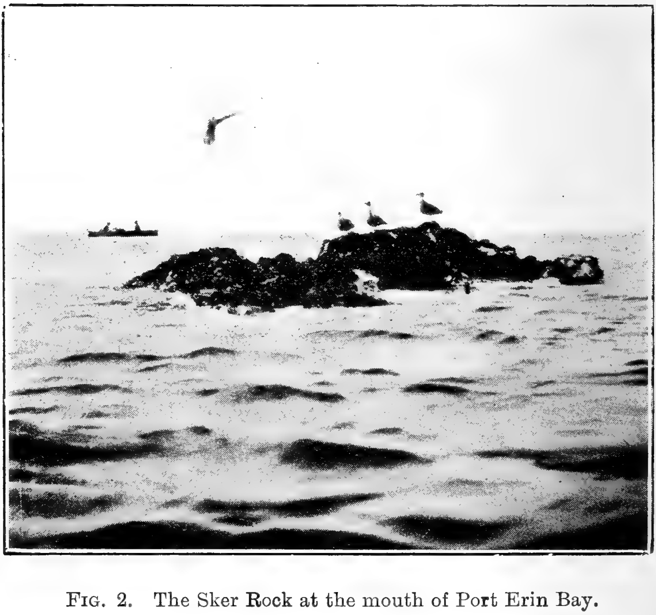


FIG. 2. The Sker Rock at the mouth of Port Erin Bay.

Appendix A.

AN ADDRESS UPON

THE LIFE AND WORK OF EDWARD FORBES

GIVEN TO THE LIVERPOOL BIOLOGICAL SOCIETY

By W. A. Herdman.

During the past year enthusiastic meetings have been held at Douglas, and by Manx Societies in London* and elsewhere to celebrate the Centenary of the birth of Edward Forbes, the distinguished Manx Naturalist, who was a notable figure in British Science during the second quarter of the nineteenth century. Both from local associations, and from the fact that his investigations may fairly be regarded as pioneer work leading up to the Marine Biology and Oceanography of the present day, it seems appropriate that a short account of the life and work of Forbes should appear in this report-for-the-year of the only marine biological institution in the land of his birth.

A century ago, in 1815, the Napoleonic wars were just ending. In the earlier part of the year when Edward Forbes was born, Waterloo had not yet been fought. Napoleon was still at large, and the state of public affairs was, in some respects, not unlike what we are passing through at present. Europe was then also an armed camp, most of the great nations were at war, and then, as now, this country was fighting, along with allies, against the greatest military power of the time—fighting for the cause of humanity and freedom against the tyranny of a military autocracy.

Before the time of the Crimean War and the Indian Mutiny, Forbes was dead; so his brief life was lived in a time

* For some of the statements in the following pages I am indebted to speeches made on these occasions, and more especially to the excellent "Memoir of Edward Forbes," published in 1861, by Professors George Wilson and Archibald Geikie.

of peace, when notable advances were made in the Arts and Sciences, and in their application to University Education, in all of which he played a prominent part.

Edward Forbes was born on the 12th of February, 1815, at Douglas, where his father was a banker. Though settled in the Isle of Man for several generations, the Forbes family was of Scottish descent, the great grandfather, who was involved in the Jacobite rising of 1745, having fled to the Island for refuge. The mother of Edward Forbes was Jane Teare, heiress of the estates of Corvalla and Ballabeg at Ballaugh, where her ancestors had lived for centuries, combining, no doubt, in their blood both the Scandinavian and the Celtic elements which are found in the Manx people. As his paternal grandmother again was English, our Naturalist, though born and bred a Manxman, was of mixed blood, and may have inherited qualities from all that is best in our complex British nation.

As seems frequently to be the case with Naturalists, it was from his mother that Forbes derived his love of nature, and more particularly his early taste for botany. It was certainly inborn in him, as we hear that at the early age of seven he had already collected and arranged a museum of natural objects, and had appointed a younger sister as Assistant Curator. He was a delicate boy, unable to go to school till the age of twelve, and it was, no doubt, to encourage these self-taught home studies that his father built an addition to their house to contain the boy's museum, and it was there that in his early youth Forbes started those collections which, in later life, formed the basis of his celebrated books on British Echinoderms and British Mollusca.

Home education in the case of a clever child probably always favours precocity, introspection and over-ambitious attempts. Still, he must have been a remarkable boy to have produced in his twelfth year "A Manual of British Natural

History in all its departments." He was, we are told, a gentle and sweet-tempered child, and probably his keenest interests were in the living things and wild nature around him. He must have been very unlike most boys of his age, and so was liable to be misunderstood and unappreciated. It is recorded that his grandmother Teare, seeing him grubbing for snails in a hedge, said (in Manx) :—" Ta mee credjal naugh vod slane Ellan Vannin sauail yn guilley shoh veich cheet dy ve ommydan " (= I believe the whole Isle of Man cannot save this boy from being a fool).

He was at school for a few years at Douglas where he is described as never having his pencil out of his hand, and as covering his books and exercises and the margins of his Latin verses with sketches of animals and caricatures and fancy pictures of all kinds.

Then he left home for good at the age of seventeen. His mother had hoped he would enter the Church, his father wished him to be a doctor. As a compromise he went to London to study Art! Although exceedingly clever with his pencil, as the illustrations in many of his books abundantly testify, four months in London convinced him that he could never be a professional artist, and he then decided to fall in with his father's wishes and study medicine in Edinburgh. It is of interest to note that at that time (1831) it took three days to travel from London to the Isle of Man and another three from there to Edinburgh.

We hear most about two of the professors during his earliest years at Edinburgh—Graham and Jameson. Graham was Professor of Botany, and it is said to have been a matter of dispute amongst his students whether it was six or seven diagrams that illustrated his course of lectures. The microscope was unknown, and the only practical work consisted in collecting flowers and pulling them apart with the fingers. Jameson, who united Geology and Zoology, was a celebrated man,

a noted Mineralogist, and the founder of the Natural History part of the well-known Museum at Edinburgh.

It is evident that what Forbes appreciated most was the collecting excursions into the country around Edinburgh, and even further afield to the Northern Highlands or to the Western Islands, which some of the Professors organised from time to time. That was really the practical work in Natural Science of those days. It is curious to recall nowadays, when we use the microscope so constantly, that the study of histology and microscopic structure in general was only introduced into medical studies, in 1841, by Professor Hughes Bennett, who had been a fellow student of Edward Forbes. Forbes was, at Edinburgh, the centre of a group of brilliant young men, some half dozen of whom, after being fellow students, later on became fellow Professors in the same University. Among these we may note John Goodsir, the great Anatomist; Balfour, the Professor of Botany; George Wilson, the biographer of Forbes; and Sir Robert Christison.

Goodsir was Forbes' first and probably his best friend. We are told that when he first called at his lodging he found the future malacologist boiling in his kettle a rare mollusc, *Clausilia nigricans*, he had found on Arthur's Seat, in order to get the animal from the shell—and Goodsir thereupon gave him a first lesson in dissecting a mollusc. We get curious glimpses of student life in Forbes' accounts—which are characteristically added up incorrectly—such as, "Leg, £2; Church, 6d.; Insects, 2/–." The "Leg" was, of course, his "part" in the dissecting room. We are told he was one of the idlest students of medicine Edinburgh ever saw—which is surely a strong statement—and yet we may be sure he was always fully employed in some interesting study, literary, artistic or scientific. The point is that he was not doing what he was intended to do, and in that sense his time was wasted. He began each lecture with serious notes, which

very soon degenerated into caricatures of the lecturer and fancy sketches of nymphs and gnomes.

His friend, Hughes Bennett, who undertook to coach him in anatomy, tells of the many dismal evenings of yawning over the bones, and of how Forbes would arrange that jovial friends should come in and interrupt—when the textbooks and bones would be thrown aside and the rest of the evening devoted to gaiety and philosophical discussions. After which it need not surprise us that when summoned to appear for examination on a certain afternoon, he at the appointed time was *non inventus*.

Of course, these young men ran a journal, and, of course, they formed a select students' club, the Brotherhood of the Magi, the symbol of which was a silver triangle on which was engraved ΟΙΝΟΣ, ΕΡΩΣ, ΜΑΘΗΣΙΣ—wine, love, learning. Their wine was not, I think, excessive; the love was brotherly love; and the learning was certainly on a high level. They were all clever, and most of them became celebrated men. This "oineromathic" brotherhood they defined as "a Union of the Searchers after Truth."

FIG. 3. The "Oineromathic" Symbol—From a prospectus of the Club now in the Zoological Departmental Library, University of Liverpool.

I have dwelt at some length on his student years in Edinburgh, as they were clearly the most stimulating and formative time of his life, definitely related to all he did later on, and brightened by friendships which persisted to the end. It was a lengthy student's career—nine years—four years of medical study, which he finally abandoned in 1836

to devote all his energies to Science. But during this time he spent considerable periods away from Edinburgh, travelling for study and always adding to his Natural History collections wherever he went.

Several summers between 1832 and 1839 he spent in dredging the Irish Sea, and exploring the fauna and flora of the Isle of Man, and we see the results later on in his first-published book "Malacologia Monensis," and in certain papers in the Annals and Magazine of Natural History.

Another summer (1833) he and a fellow student explored far from beaten tracks in Norway, going in a trading brig from Ramsey to Arendal, and then shouldering their knapsacks and packs of scientific collecting apparatus, which, no doubt, became heavier day by day as the collections grew. He had, of course, the noticing eye and the acquisitive hand of the true collector. On arriving at Bergen, his first action was to note that a spitting box or spittoon in the room he entered was filled with a fine shell-sand, which he promptly emptied into his handkerchief and took away with him for microscopic examination. Another year he spent some time in Paris, and the following summer made an expedition to Algeria. In 1839, he and Goodsir were dredging in the Shetland Seas, with results which Forbes made known to the meeting of the British Association at Birmingham that summer with such good effect that a "Dredging Committee" of the Association was formed to continue the good work.

It was at this meeting of the Association that Forbes and his friends founded the "Red Lion Clubbe," which still meets, not with the regularity of its early days, but on occasions, for jovial dinners and good fellowship—the old "Lions," and even the youngsters or "Cubs," under the presidency of the "Lion King," roaring and growling their approval and disapproval, and even getting up and waving their (coat-) tails, while some make witty speeches and others sing amusing songs,

generally specially composed for the occasion, and as often as not parodying in a good-natured way some of the serious papers or addresses given to the Association at the meeting. Just as some of Forbes' best work was expounded in successive years to the British Association, so some of the happiest of

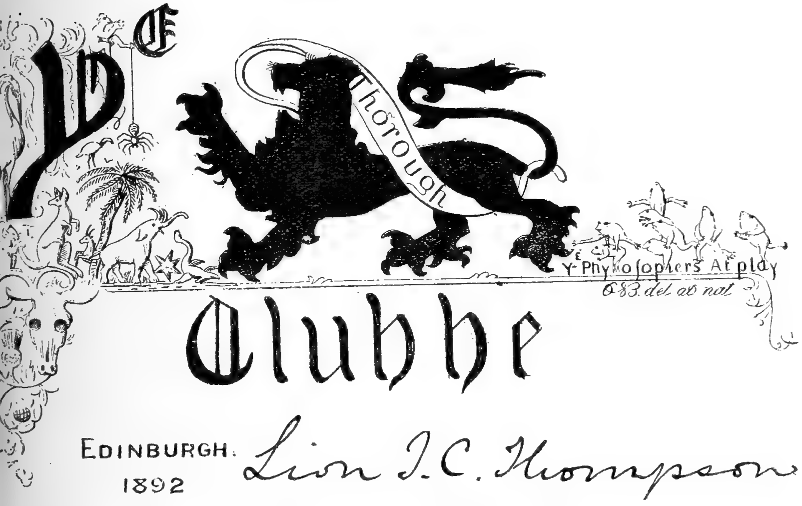


FIG. 4. Invitation card of the Red Lion Clubbe dinner.

his lighter efforts first made their appearance at the Red Lion dinners. In this particular year (1839), when he gave the scientific results of his Shetland dredgings to the Section, he sang or chanted to the Red Lions his "Song of the Dredge," of which I may quote a few verses here :—

Hurrah for the dredge, with its iron edge,
  And its mystical triangle,
And its hided net with meshes set
  Odd fishes to entangle !
The ship may move thro' the waves above,
  'Mid scenes exciting wonder,
But braver sights the dredge delights
  As it roves the waters under.

Chorus : Then a-dredging we will go, wise boys !
  A-dredging we will go !
A-dredging we will go, a-dredging we will go,
  A dredging we will go, wise boys, wise boys,
A-dredging we will go !

Down in the deep, where the mermen sleep,
  Our gallant dredge is sinking;
Each finny shape in a precious scrape
  Will find itself in a twinkling!
They may twirl and twist, and writhe as they wist
And break themselves into sections,
But up they all, at the dredge's call,
  Must come to fill collections.

Then a-dredging, etc.

The creatures strange the sea that range,
  Though mighty in their stations,
To the dredge must yield the briny field
  Of their loves and depredations.
The crab so bold, like a knight of old,
  In scaly armour plated,
And the slimy snail, with a shell on his tail,
  And the star-fish—radiated!

Then a-dredging, etc.

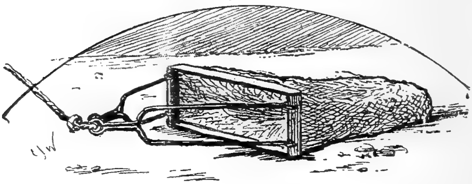


FIG. 5. Naturalist's Dredge.

And on another occasion, when at the Oxford Meeting in 1847 there had been a notable discussion on the nature and relations of the extinct Dodo, Forbes brought out his "Song of the Do-do," of which the following are some of the verses:—

Do-do! Vasco da Gama
Sailed from the Cape of Good Hope with a crammer,
How he had met, in the Isle of Mauritius,
A very queer bird wot was not very vicious,
Called by the name of a do-do;
And all the world thought what he said was true.

Do-do! although we can't see him
His picture is hung in the British Museum;
For the creature itself, we may judge what a loss it is
When it's claw and it's bill are such great curiosities.
Do-do! Do do!
Ornithologists all have been puzzled by you.

Do-do! John Edward Gray, sir,
Doubted what Mr. Blainville did say, sir,
And held that the bird was a vile imposition,
And that the old Dutchman had seen but a vision.
A do-do! a regular do!
And didn't believe one word was true.

Moral: Do-do! alas there are left us
No more remains of the Didus ineptus,
And so in the progress of science all prodigies
Must die, as the palm-trees will some day at Loddiges,
And like our wonderful do-do,
Turn out not worth the hullabaloo.

During his last few years at Edinburgh, Forbes made strenuous efforts to earn a livelihood by science. He prepared and announced courses of lectures at Edinburgh, St. Andrews and elsewhere, which, I fear, were but poorly attended and probably little more than paid expenses. It is interesting to notice that in January, 1840, he gave a course of eight lectures in Liverpool.

It was probably on the occasion of these lectures that he made the acquaintance of Mr. Robert MacAndrew, a Liverpool merchant and yachtsman, interested in the mollusca, who, during the last decade or so of Forbes' life, frequently took him, and Goodsir or other friends, on shorter or longer dredging expeditions.* For example, in the summer of 1845 we find that he was with MacAndrew on his yacht dredging in Shetland Seas, and on the way back amongst the sea-lochs of the Hebrides. On other occasions MacAndrew took him in the yacht to dredge Milford Haven, or off the Coast of Cornwall, or other localities which Forbes required to examine in connection with the great work on the British Mollusca upon which he was then engaged. Again, we find Forbes and Goodsir in their important paper, "On some remarkable

* I am glad to have the opportunity of paying this tribute to a Liverpool yachtsman who found or helped to find many of the rarer Mollusca of British Seas. His name occurs frequently in the records of Forbes and Hanley's "British Mollusca," and it is perpetuated in science in *Calocaris macandreae*, one of the rarer deep-water Crustacea, and in the names of several species of new shell-fish which he had been instrumental in discovering.

Marine Invertebrata new to the British Seas," published by the Royal Society of Edinburgh in 1851, recording that :—" The animals, either wholly new, or new to Britain, described in the following communication, were taken during a yachting cruise with our indefatigable friend, Mr. MacAndrew, among the Hebrides, in the month of August, 1850." Amongst the strange animals described and figured in this paper is the remarkable Ascidian, *Diazona violacea* (the *Syntethys hebridica* of Forbes and Goodsir), which was discussed somewhat fully in a recent number of this Annual Report (No. 26, for 1912).

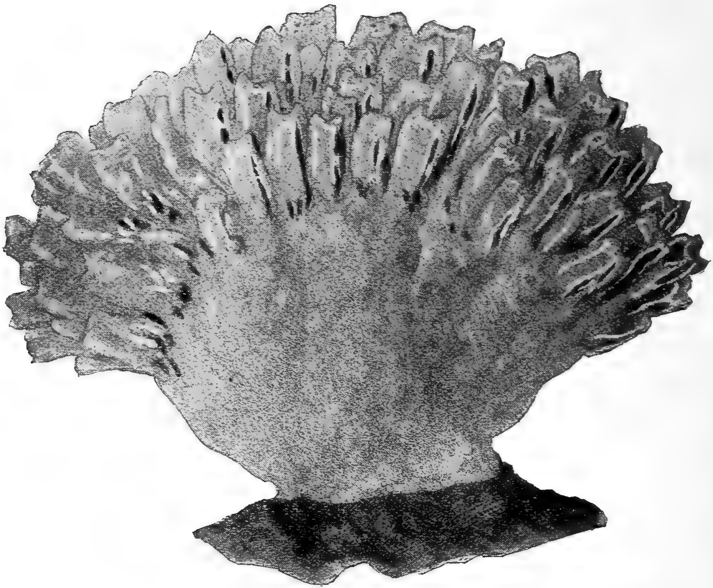


FIG. 6. *Diazona violacea* in the living condition (After Forbes and Goodsir.)

Returning to 1840, his age was now twenty-six, and this was the year when he published his " British Starfishes "—the first of his larger and more important works. It remained as the standard work on the subject for many years, and is

still a classic. In addition to its solid science and its value as a work of reference, there are scattered through it touches of humour, and the artistic and sometimes quaintly comic vignettes and tail-pieces, with which the author's pencil has adorned the beginnings and ends of the sections, are a pleasing feature of the work. Let me quote just one passage, his description of the dredging of the Starfish, *Luidia fragilissima* (as it was appropriately named at that time).

"The first time I ever took one of these creatures I succeeded in getting it into the boat entire. Never having seen one before, and quite unconscious of its suicidal powers, I spread it out on a rowing bench, the better to admire its form and colours. On attempting to remove it for preservation, to my horror and disappointment I found only an assemblage of rejected members. My conservative endeavours were all neutralised by its destructive exertions, and it is now badly represented in my cabinet by an armless disk and a diskless arm. Next time I went to dredge on the same spot, determined not to be cheated out of a specimen in such a way a second time, I brought with me a bucket of cold fresh water, to which article Starfishes have a great antipathy. As I expected, a *Luidia* came up in the dredge, a most gorgeous specimen. As it does not generally break up before it is raised above the surface of the sea, cautiously and anxiously I sunk my bucket to a level with the dredge's mouth, and proceeded in the most gentle manner to introduce *Luidia* to the purer element. Whether the cold air was too much for him, or the sight of the bucket too terrific, I know not, but in a moment he proceeded to dissolve his corporation, and at every mesh of the dredge his fragments were seen escaping. In despair I grasped at the largest, and brought up the extremity of an arm with its terminating eye, the spinous eyelid of which opened and closed with something exceedingly like a wink of derision." (" British Starfishes," p. 138.)

In turning over these earlier works of Forbes, we think of him as the typical "field-naturalist" of the older days, when it was still possible to take all nature for your province and do useful work in many fields—constantly investigating, constantly observing wherever he went, and throwing welcome light on science by all his observations.

All Forbes' later and more famous work in Marine Biology and the relations between Zoology and Geology—work that extended from Hebridean and Scandinavian Seas, through the Mediterranean to the far Ægean—may be said to have sprung from and been founded on his early work done as a lad in the college vacations in his home Manx waters.

A little to the north of Peel, on the West Coast of Man, lies a submarine elevation, the Ballaugh fishing bank, which was the scene of some of Forbes' earliest explorations—about eighty years ago. The path of the pioneer is proverbially rough, and no doubt it is easier for us now, when, on occasions, we take our students to the Ballaugh Bank for a day's dredging from Port Erin. Forbes, in his day, must have gone in a small sail-boat from the shore below his house, or possibly in one of the "nobbies" of the Peel fishing fleet, and was certainly more dependent upon wind and weather than is now the case, when we can steam to the bank from Port Erin in an hour or two, and carry on our work there without much regard to wind or tide, in any moderate weather. But we find, in going over Forbes' records from Ballaugh, that his work was wonderfully detailed and accurate, and there is little or nothing to add. He found nearly all there is to find, and he marked out the distribution of life upon the various depths and parts of the bank with remarkable precision. And that, I think, is characteristic of much of his work. That he did so much, and did it so well in so short a life, full of other duties and cares, must constantly excite the wonder and admiration of those who humbly follow in his footsteps.

British naturalists are justly proud of the thorough manner in which the contents of the home seas have been made known by their distinguished predecessors; and of these famous monographs, which will remain classics of science throughout all time, some of the chiefest glories both in text and plates are those bearing the honoured name of Edward Forbes.

In 1841 came the great opportunity of his life to make marine investigations outside the British Seas. Captain Graves, then in command of H.M. Surveying Ship "Beacon," engaged on hydrographical work in the Eastern Mediterranean, offered Forbes the post of naturalist to the expedition, which was promptly accepted. The work so far as Forbes was concerned was partly on land and partly at sea, partly zoological and partly archæological. After some months of surveying and dredging amongst the Isles of Greece, the "Beacon" was ordered to the coast of Lycia for the purpose of conveying to England the remarkable carved marbles and inscriptions discovered in the ruins of the ancient city of Xanthus by Sir Charles Fellows. For this task the vessel proved eventually to be quite unfitted, but it gave the opportunity for Forbes, along with Lieut. Spratt, to join the archaeologist, Mr. Daniell, in a series of important explorations in the interior of Lycia, in the course of which they determined the sites of no fewer than eighteen ancient cities previously unknown, and rescued many inscriptions and carvings from the ruins. They copied upwards of 200 Greek and 30 Lycian inscriptions, and Forbes and Spratt a few years later (1847) produced an interesting work in two volumes entitled "Travels in Lycia," giving the story of their explorations. In addition to his share of the narrative and the archaeology, the chapters on the Natural History of Lycia and the neighbouring seas are clearly the work of Forbes. Mr. Daniell fell a victim to the malignant malarial fever of the country, and Forbes himself apparently

had a narrow escape. His companion, writing in 1842, says: "Poor Forbes, the Naturalist, was taken ill on the way from Rhodes to Syra, of the country fever, and remained for thirteen days together without tasting food, and without medicine or medical advice."

During this expedition, however, his main work was not on land, but at sea; and his marine dredgings in the Ægean gave great results. Captain Graves tells us how Forbes converted everyone on board—officers and men alike—into ardent naturalists, bringing back shells and other offerings, "curios" as they called them, from every surveying trip in the boats.

Of the Greeks, in one letter, he foretells—"they will be a great people yet, and are almost as interesting as the shell-fish that live on their shores." One of the points of interest, of course, in the shell-fish was that they and many of his other captures were precisely the animals collected and described by Aristotle from these same coasts over 2,000 years before. He dredged successfully at a greater depth (230 fathoms) than anyone had done before, and to his surprise he brought up living starfishes and other animals from 200 fathoms. He writes that the shell-fish from the deeper water all belong to types only known in the fossil condition, and that, so far, he is the only zoologist who has seen them alive. His Report on the distribution of animals in the Ægean Sea, which eventually appeared before the British Association at Cork in 1843, was, a contemporary tells us, a most important and philosophic summary of the facts, which at once raised him to a high rank among living naturalists. He defined, in the Ægean, eight zones of depth characterised by peculiar assemblages of animals, and he "conjectured that the zero of animal life would probably be found somewhere about 300 fathoms"—so he named the region below that, the "Azoic zone"—a conclusion which has since been found to be erroneous.

Much of his zoological work in the East was unfortunately never published, on account of the pressure of other duties in which he became absorbed on his return to London.

The Council of the British Association gave him congratulations and encouragement, and the material support of a grant of £100, "to be expended in comparing the fauna of the Red Sea with that of the Mediterranean." Forbes therefore planned an extended expedition to Egypt for this purpose, which was first postponed by his severe illness and then abandoned when he was recalled in October, 1842, to London to take up the duties of Professor of Botany at King's College—a post he had been elected to in his absence.

There were probably few men then, and there are none now, who could be elected to a post in Botany, in Geology, or in Zoology with equal success. We see him now holding two such posts simultaneously, and he eventually went on to the third. His professorship at King's College brought in less than £100 a year, so he had to supplement that scanty income by taking other work, and he applied for and was appointed to the Curatorship of the Geological Society, and a few years later (1844) to the more important post of Palæontologist to the Geological Survey.

During the years in London when he filled these several posts, it is evident that his duties as Professor of Botany took up comparatively little of his time and energies, and that he was then, in fact, mainly a Geologist. He identified himself thoroughly and intimately with the members of the Geological Society and with his colleagues of the Geological Survey, with whom, of course, he was constantly working both in the field and at the Jermyn Street Museum. His work as Palæontologist was to identify the large numbers of fossils collected by the surveyors, and to give any information he could as to the conditions under which they had lived. In all this work, which occupied some of the best years of his

life, he was, however, what he called a "Zoo-Geologist," working on the border-line of the two sciences and throwing light on both, bringing zoological knowledge in regard to the animals represented by the fossils to bear upon geological problems, and showing on the other hand how geological changes in the past help to explain the distribution of animals and plants at the present day. In some respects this was the finest and most original work that he ever did. During this period he was one of the founders of the Palæontographical Society, which has issued a noble series of volumes, some of the earlier of which (e.g., British Tertiary Echinoderms) are Forbes' work. He also contributed largely to other geological publications.

We can only mention two of the more important of these pieces of work. One of these was his careful investigation of the layers of supposed Wealden rocks, known as the Purbeck beds. In the autumn of 1849 he went down to the coast of Dorset and spent some months making a most minute investigation of the strata, with the result that he proved that these beds really belong to the Oolitic series. Sir Archibald Geikie tells us that, "with magnifying glass at eye he crept over the faces of the rock, layer by layer, noting the peculiarities of each from top to bottom. As the result of this detailed scrutiny, while there was no evidence that any physical disturbance had taken place in the area during the deposition of the whole of the strata, the testimony of the included fossils revealed a remarkable series of alternations of fresh, brackish, and salt-water conditions over this part of England when the Purbeck group was in course of deposition. Our naturalist made the further important discovery that on several separate horizons these strata enclose the shells of some living genera of air-breathing mollusks—creatures which had not till then been found in so ancient a formation. It was characteristic alike of his humour and of his habit of making fun of his

scientific brethren, and even of himself, that in some verses on what he called 'Negative Facts,' given at the Red Lion Dinner at Ipswich, and published in the 'Literary Gazette' for 12th July, 1851, he instanced the finding of these shells as upsetting a premature conclusion.

> Down among the Purbecks deep enough,
> A Physa and Planorbis
> Were grubbed last year out of freshwater stuff,
> By Bristow and E. Forbes.
> (Agassiz just had given his bail
> 'Twas adverse to creation
> That there should live pulmoniferous snail
> Before the Chalk formation.)

The discovery, however, carried with it a wider significance. The occurrence of these snails suggested to Forbes that if air-breathing mollusks existed in Purbeck time, remains of mammalian life might hopefully be searched for in the same stratum as that which contained the shells. His sagacious prognostication was fulfilled not long after, when bones of reptiles and insectivorous mammals were exhumed where he had indicated."

The second example of Forbes' geological work which I have selected for mention is his celebrated paper "On the connexion between the Distribution of the Existing Fauna and Flora of the British Isles and the Geological Changes which have affected their area," published in 1846, in Vol. I. of the Memoirs of the Geological Survey, and universally regarded as a classic on the subject.

Forbes recognised that the origin of the fauna and flora of a country could not be solved from biological studies alone, but would require in addition the evidence supplied by Geology in regard to former changes in climate, land and water. Dealing with the flora of the British Islands he distinguished five sub-floras or assemblages of plants—(1) a limited "Lusitanian" flora in the west and south-west of Ireland, comprising saxifrages, heaths, the arbutus, a Pinguicula, and

other plants which are identical with species found abundantly in the north of Spain; (2) another local flora in the south-west of England and south-east of Ireland, resembling the vegetation of the Channel Isles and north-western France; (3) a restricted flora found on the chalk downs of the south-eastern counties of England; (4) a remarkable though limited flora, flourishing on the tops of the mountains, chiefly in Scotland, but also on the hills of Cumberland and Wales, and even on some uplands in Ireland, in which vegetation all the plants are specifically identical with Scandinavian forms; (5) and last, a general or Germanic flora, like that of Central Europe, everywhere present either alone or mingled with the others.

Forbes accounted for this distribution of the flora by migration or colonisation from neighbouring lands previous to the isolation of the British Islands from the rest of Europe. He supposed that the southern parts of our islands were probably not submerged under the glacial sea, and that over land now covered his three southern assemblages of plants may have migrated successively northwards from Spain and from France, before, during or after the Ice Age. If the floor of our seas was raised by even 100 fathoms, the British Isles would become a part of the European continent, the North Sea would become a great plain continued south and west through what is now the English Channel, and a strip of land would run from Britain along the west coast of France so as to join the north of Spain. This was the "Continental Platform" over which, according to Forbes, the plants, and even possibly some of the lower land animals, may have migrated into the south and west of Ireland.

The fauna of our seas also, like the land flora, presents distinct northern and southern relations. This is clearly seen both amongst the invertebrata, such as the molluscs, and also amongst fishes. In discussing these relations, one of the most interesting points that Forbes demonstrated was the presence

of "Boreal Outliers" or assemblages of northern species occupying the deeper areas of about 80 to 100 fathoms that occur here and there on the West Coast of Scotland. Such molluscs as *Puncturella noachina, Trichotropis borealis, Natica groenlandica, Astarte elliptica, Nucula pygmaea, Emarginula crassa, Pecten danicus, Neaera cuspidata,* and the brachiopods *Terebratula caput-serpentis* and *Crania norvegica,** are characteristic forms in these boreal outliers, and Forbes' view was that they were a part of the original northern fauna which formerly occupied our seas and which had retreated northwards when the climate became more genial subsequent to the glacial epoch, leaving these colonies isolated in the deeper holes.

Some of the chief conclusions, to which the facts and arguments stated in his detailed memoir lead, he summarises as follows :—

"(1) The fauna and flora, terrestrial and marine, of the British Islands and seas have originated so far as that area is concerned since the Miocene epoch.

(2) The assemblages of animals and plants composing that fauna and flora did not appear in the area they now inhabit simultaneously but at several distinct points of time.

(3) Both the fauna and flora of the British Islands and seas are composed partly of species which appeared in that area before the glacial epoch, partly of such as inhabited it during that epoch, and in great part of those which did not appear there until afterwards.

(4) The greater part of the terrestrial animals and flowering plants now inhabiting the British Islands arose outside that area and have migrated to it over continuous land.

(5) The Alpine floras of Europe and Asia are fragments of a flora which was diffused from the North. The deep sea fauna is in like manner a fragment of the general glacial fauna.

(6) The termination of the glacial epoch in Europe was

* I have given throughout the names as used by Forbes.

marked by a recession of the Arctic fauna and flora northwards, and of a fauna and flora of the Mediterranean type southwards, and in the interspace thus produced there appeared on land the general Germanic fauna and flora, and in the sea that fauna which is termed Celtic.

(7) All the changes before, during and after the glacial epoch appear to have been gradual and not sudden, so that no marked line of demarkation can be drawn between the creatures inhabiting the same element and the same locality during two proximate periods."

I have omitted some of his conclusions which can no longer be regarded as based on fact: others require some modification. Much has been found out during the last seventy years, and it is not surprising if some of Forbes' brilliant and far-reaching speculations have proved incorrect or incomplete. For example, the three southern sub-floras of Forbes, in place of being the oldest as he supposed, we now know must have been the most recent; and it is now very doubtful to what extent they migrated over continental land now submerged, as he supposed, or were not rather carried by birds, currents or other natural agencies.

But while admitting some such imperfections due to the scanty knowledge of that day, we must recognise that this was a notable contribution to the theory of distribution, far in advance of anything known at the time. It practically opened up a fresh field of investigation, and proved to be the starting point and stimulus of much subsequent research.

There are many of his writings, and of his lectures, which I have no space to refer to—though all have their points of interest. Take this, for example:—In 1847, he writes to a friend, " On Friday night I lectured at the Royal Institution. The subject was the bearing of submarine researches and distribution matters on the fishery question. I pitched into Government mismanagement pretty strong, and made a fair

case of it. It seems to me that at a time when half the country is starving we are utterly neglecting or grossly mismanaging great sources of wealth and food . . . Were I a rich man I would make the subject a hobby, for the good of the country and for the better proving that the true interests of Government are those linked with and inseparable from Science."

I have laid more stress upon Forbes' theoretical papers than upon his matter of fact descriptive works. Useful as these latter are, indispensable to the systematic zoologist and palaeontologist, works some of them, such as Forbes and Hanley's "British Mollusca" (published in 4 vols. between 1848 and 1853), which will remain as classics for all time, still they are books to consult rather than to read. On the other hand, his theories—such as those on the distribution of marine animals in the Mediterranean, and on the relations of the British fauna and flora to the great Ice Age, even if in some respects they are now regarded as erroneous or incomplete—have had a position and an influence in the history of science, have been an inspiration to many both in his own generation and since, and have led up to and guided the very researches which have, in some cases, resulted in more correct views. His theory of the "Azoic Zone" in the sea, that no life existed below 300 fathoms, based upon his observations in the Eastern Mediterranean, was justified by the facts known at the time, but required to be modified later on when the deep-sea dredging expeditions, which Forbes' work had stimulated, made known that an abundant living fauna extended down to the greatest depths of the abysses.

Taken altogether, it is a wonderful volume of work both in quantity and quality for a man to have produced who died before reaching the age of forty. His working life, even considering that he began original work very young, was limited to about twenty years, and it is reasonable to suppose that had he lived he would have made Edinburgh the greatest

centre of marine biological work in Europe. That was evidently the opinion of his contemporaries. It is on record that he was worshipped by the men, old and young, who attended his first and only course of lectures in Edinburgh. They spoke of the wonderful influence, charm and fascination that Forbes exercised on all who came in contact with him, and of the gloom and consternation which spread over the University when it was realised that he would never again meet his class.

Forbes was appointed to the goal of his ambition, the Chair of Natural History, at Edinburgh, in March, 1854. He gave a course of lectures in the summer term to a large and enthusiastic audience, after which he returned to London to finish off work for the Geological Survey until driven to take a brief holiday in the country by a severe attack of illness. In September the British Association met in Liverpool, and Forbes occupied the honourable position of President of the Geological Section in which we are told he acquitted himself with great distinction—as he did likewise when presiding, in the character of a Scottish Lion, at the Red Lion Dinner during the same meeting.

His last published article, written at this time, a review of Sir R. Murchison's " Siluria," contains a memorable passage, beginning :—

" The old Scandinavian gods amused themselves all day in their Valhalla hacking each other to small pieces, but when the time of feasting came, sat down together whole and harmonious, all their wounds healed and forgotten. Our modern Thors, the hammer-wielders of Science, enjoy similar rough sport with like pleasant ending." His purpose was to show that scientific disputes need not lead to unfriendly relations—that after tearing each other to pieces, metaphorically, in the section room the protagonists can dine together amicably as "Red Lions."

There is no doubt that he was in poor health during this

summer, and had had no adequate rest. He returned to Edinburgh in October to prepare for his winter course, which started on November 1st. But after a week's lecturing he broke down completely from weakness and an attack of fever, which soon showed symptoms of kidney trouble, and became rapidly worse, leading to his death a few days later. His old friend, Professor Hughes Bennett, who was with him to the last, in an obituary notice, states :—" A chronic disease contracted when in the East, re-excited and rendered violent by a severe cold caught last autumn, and which burst out with uncontrollable fury about ten days ago, was the immediate cause of his premature death."

In judging of the man it is important to bear in mind the dominating influence of his personality and conversation, quite apart from his publications. Few can now be alive who have held converse with him, but from remarks in the writings of his contemporaries we gain the impression of a genial and lively genius, with a free and independent spirit that roamed over a wide range in quest of knowledge and occupation.

Although an ardent student, he was far from being the recluse or the typical absent-minded " philosopher," as the man of science was called in those days. Accomplished, and with high social gifts, he appreciated versatility and sportsman-like qualities in others, and he once stated (in an article on Sir Humphrey Davy's " Salmonia ") that he " would undertake, without travelling far, to furnish philosophers, of various scientific callings, who could ride a race, hunt a fox, shoot a snipe, cast a fly, pull an oar, sing a song, or mix a bowl, against any man with unexercised brains, or even with none at all, in the United Kingdom." Mixing of bowls has gone out of fashion in scientific circles, but with that exception, and with such additions as may have resulted from the developments of sport and locomotion, the boast might be repeated of the " philosophers " of the present generation.

Forbes was certainly the most brilliant and inspiring naturalist of his day—a day when it was still possible to make original contributions to knowledge in several departments of nature. As we have seen, he held posts successively as Professor of Botany in London, as Palaeontologist to the Geological Survey, and as Professor of Natural History in Edinburgh; but to my mind the best description in brief form is that he was the pioneer of oceanography—the science of the sea.

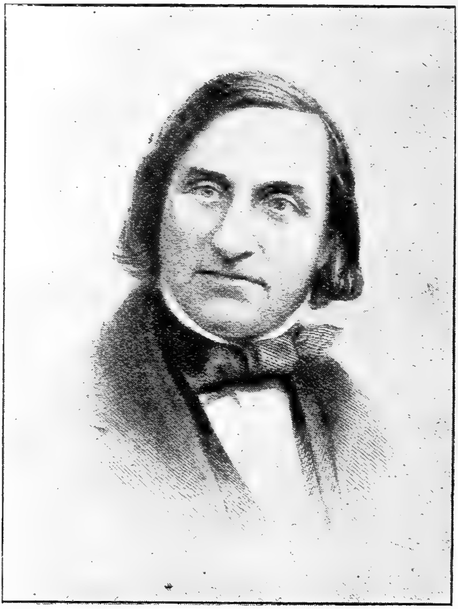


FIG. 7. From the portrait in Wilson and Geikie's Memoir.

It is true that the term oceanography was not coined till much later, and that Forbes in his marine explorations probably did not realise that he was opening up a most comprehensive and important department of knowledge. But

it is also true that in all his expeditions—in the British seas from the Channel Islands to the Shetlands, in Norway, in the Mediterranean as far as the Aegean Sea—his broad outlook on the problems of nature was that of the modern oceanographer, and he was the spiritual ancestor of men like Sir Wyville Thomson, of the Challenger Expedition, and Sir John Murray, whose recent accidental death, in the midst of active work, was an irreparable loss to this new and rapidly advancing science of the sea.

Forbes in his marine investigations, as we have seen, worked at border-line problems, dealing for example with the relations of Geology to Zoology, and the effect of the past history of the land and sea upon the distribution of plants and animals at the present day, and in these respects he was an early oceanographer. For the essence of that new subject is that it also investigates border-line problems and is based upon, and makes use of all the older fundamental sciences—Physics, Chemistry, and Biology—and shows for example how variations in the great ocean currents may account for the movements and abundance of the migratory fishes, and how periodic changes in the chemical characters of the sea are co-related with the distribution at the different seasons of the all-important microscopic organisms that render our oceanic waters as prolific a source of food as the pastures of the land.

Oceanography is as yet scarcely known in the Universities, and when it does come to be recognised and provided for, it will probably be as a research department, carrying on investigations partly by experiments in the University laboratories on shore, partly by observations on special expeditions at sea, and partly no doubt by the accumulation and comparison of data as to temperatures and salinities, obtained from commercial vessels making ocean traverses—all on the lines shown by the magnificent "Musée Océanographique" at

Monaco, and also by the programme of work of the "Conseil Permanent International pour l'exploration de la Mer," a scheme of co-operation between the nine or ten maritime nations of North-West Europe (unhappily now in abeyance on account of the war), and, I think I may add, although the methods and the objects may now be very different, also quite in the spirit of the pioneer work performed in the Irish Sea by Edward Forbes seventy to eighty years ago.

It must always remain an interesting speculation as to what part Edward Forbes would have played, had he lived, in the great controversy which raged a few years later round the Darwinian theory of Evolution by means of Natural Selection. Forbes and Darwin were practically contemporaries,* but whereas Forbes' life work was ended in 1854, Darwin's more celebrated works were not published until after 1858, the year when he and Wallace laid their epoch-making communication upon the Origin of Species before the Linnean Society of London.

Forbes, at the time of his death was, in the opinion of his contemporaries, the most original naturalist of the time, and he had certainly had as much to do with the recognition and description of species—species of animals, of plants and of fossils—as anyone of his day. Would this knowledge have helped him to appreciate Darwin's new views, or would it have confirmed him in the more orthodox opinions of the time? Huxley was his junior by ten years, and Huxley was the protagonist of Darwinian Evolution. Would Forbes have been found in the same camp, or would he have been one of those more senior men in regard to whom Darwin said that he did not expect to convince experienced Naturalists whose minds had been accustomed during many years to an opposite point of view, but looked with confidence

* Darwin was precisely six years senior, being born on February 12th, 1809.

"to young and rising Naturalists, who will be able to view both sides of the question with impartiality"* ?

When reading Forbes' views on specific and generic centres of distribution, or his work in tracing the migrations of species both in space and time, or the description of his great map of "homoiozoic belts," one feels that surely he was not far from a belief in the mutability and community of descent of organic forms, and that had he lived he must have readily seen that the Darwinian theory gave a reasonable explanation of the great series of facts in distribution which his industry had collected and his genius had marshalled. These, taken along with his unrivalled palaeontological knowledge, are the grounds for hoping that Forbes would have been found with Huxley in the Darwinian camp.

In the entrance hall of the Port Erin Biological Station, the most conspicuous object is the large white bust† of Edward Forbes, whose clear-cut intellectual features and genial expression at once arrest the eye, and appear to preside over the activities and destiny of the institution. And what better position could there be for this finely-formed reminder of the Manx pioneer of science than in this workshop of Manx marine biology, devoted to the continuation and extension of Forbes' work in his native land ? For here, all researchers who work in the laboratory, everyone of the hundreds of senior students who enter on a course of study at Port Erin, and all who care of the many thousands of visitors who frequent the Aquarium, recognise or learn who Professor Edward Forbes was, and what he did. His works are in our library at the Biological Station, the starfishes and molluscs he described so well with pen and pencil are in the sea before our doors, his home at Ballaugh is almost in sight. In all

* Origin of Species, 6th Edition, p. 423.

† Presented to the Institution by Mr. P. M. C. Kermode, of Ramsey.

our work at Port Erin, we keep his words, as well as his familiar features, constantly before us as an example and an inspiration.

We hope in the Island to have some day a worthy Manx National Museum, at Douglas, and when that temple of the natural and antiquarian sciences comes to be reared, one of the principal halls—designed to contain the vast collections of marine biology, and to illustrate the applications of that science to the sea-fisheries—will surely be dedicated to the immortal memory of Edward Forbes, the great Manx naturalist, who first made known the abundant treasures of our seas.

Appendix B.

THE LIVERPOOL MARINE BIOLOGY COMMITTEE (1915).

His Excellency the Right Hon. Lord Raglan, Lieut.-Governor of the Isle of Man.

Rt. Hon. Sir John Brunner, Bart.

Prof. R. J. Harvey Gibson, M.A., Liverpool.

Mr. W. J. Halls, Liverpool.

Prof. W. A. Herdman, D.Sc., F.R.S., F.L.S., Liverpool. Chairman of the L.M.B.C., and Hon. Director of the Biological Station.

Mr. P. M. C. Kermode, Ramsey, Isle of Man.

Prof. Benjamin Moore, F.R.S., London.

Sir Charles Petrie, Liverpool.

Mr. E. Thompson, Liverpool, Hon. Treasurer.

Mr. A. O. Walker, F.L.S., J.P., formerly of Chester.

Mr. Arnold T. Watson, F.L.S., Sheffield.

Curator of the Station—Mr. H. C. Chadwick, A.L.S.

Assistant—Mr. T. N. Cregeen.

CONSTITUTION OF THE L.M.B.C.

(Established March, 1885.)

I.—The OBJECT of the L.M.B.C. is to investigate the Marine Fauna and Flora (and any related subjects such as submarine geology and the physical condition of the water) of Liverpool Bay and the neighbouring parts of the Irish Sea and, if practicable, to establish and maintain a Biological Station on some convenient part of the coast.

II.—The COMMITTEE shall consist of not more than 12 and not less than 10 members, of whom 3 shall form a quorum; and a meeting shall be called at least once a year for the purpose of arranging the Annual Report, passing the Treasurer's accounts, and transacting any other necessary business.

III.—During the year the AFFAIRS of the Committee shall be conducted by an HON. DIRECTOR, who shall be Chairman of the Committee, and an HON. TREASURER, both of whom shall be appointed at the Annual Meeting, and shall be eligible for re-election.

IV.—Any VACANCIES on the Committee, caused by death or resignation, shall be filled by the election at the Annual Meeting of those who, by their work on the Marine Biology of the district, or by their sympathy with science, seem best fitted to help in advancing the work of the Committee.

V.—The EXPENSES of the investigations, of the publication of results, and of the maintenance of the Biological Station shall be defrayed by the Committee, who, for this purpose, shall ask for subscriptions or donations from the public, and for grants from scientific funds.

VI.—The BIOLOGICAL STATION shall be used primarily for the Exploring work of the Committee, and the SPECIMENS collected shall, so far as is necessary, be placed in the first

instance at the disposal of the members of the Committee and other specialists who are reporting upon groups of organisms; work places in the Biological Station may, however, be rented by the week, month, or year to students and others, and duplicate specimens which, in the opinion of the Committee, can be spared may be sold to museums and laboratories.

LIVERPOOL MARINE BIOLOGICAL STATION AT PORT ERIN.

General Regulations.

I.—This Biological Station is under the control of the Liverpool Marine Biology Committee, the executive of which consists of the Hon. Director (Prof. Herdman, F.R.S.) and the Hon. Treasurer (Mr. E. Thompson).

II.—In the absence of the Director, and of all other members of the Committee, the Station is under the temporary control of the Resident Curator (Mr. H. C. Chadwick), who will keep the keys, and will decide, in the event of any difficulty, which places are to be occupied by workers, and how the tanks, boats, collecting apparatus, &c., are to be employed.

III.—The Resident Curator will be ready at all reasonable hours and within reasonable limits to give assistance to workers at the Station, and to do his best to supply them with material for their investigations.

IV.—Visitors will be admitted, on payment of a small specified charge, at fixed hours, to see the Aquarium and Museum adjoining the Station. Occasional public lectures are given in the Institution by members of the Committee.

V.—Those who are entitled to work in the Station, when

there is room, and after formal application to the Director, are :—(1) Annual Subscribers of one guinea or upwards to the funds (each guinea subscribed entitling to the use of a work place for three weeks), and (2) others who are not annual subscribers, but who pay the Treasurer 10s. per week for the accommodation and privileges. Institutions, such as Universities and Museums, may become subscribers in order that a work place may be at the disposal of their students or staff for a certain period annually ; a subscription of two guineas will secure a work place for six weeks in the year, a subscription of five guineas for four months, and a subscription of £10 for the whole year.

VI.—Each worker is entitled to a work place opposite a window in the Laboratory, and may make use of the microscopes and other apparatus, and of the boats, dredges, tow-nets, &c., so far as is compatible with the claims of other workers, and with the routine work of the Station.

VII.—Each worker will be allowed to use one pint of methylated spirit per week free. Any further amount required must be paid for. All dishes, jars, bottles, tubes, and other glass may be used freely, but must not be taken away from the Laboratory. Workers desirous of making, preserving, or taking away collections of marine animals and plants, can make special arrangements with the Director or Treasurer in regard to bottles and preservatives. Although workers in the Station are free to make their own collections at Port Erin, it must be clearly understood that (as in other Biological Stations) no specimens must be taken for such purposes from the Laboratory stock, nor from the Aquarium tanks, nor from the steam-boat dredging expeditions, as these specimens are the property of the Committee. The specimens in the Laboratory stock are preserved for sale, the animals in the tanks are for the instruction of visitors to the Aquarium, and as all the expenses of steam-boat dredging expeditions are defrayed by the Committee, the

specimens obtained on these occasions must be retained by the Committee (*a*) for the use of the specialists working at the Fauna of Liverpool Bay, (*b*) to replenish the tanks, and (*c*) to add to the stock of duplicate animals for sale from the Laboratory.

VIII.—Each worker at the Station is expected to prepare a short report upon his work—not necessarily for publication—to be forwarded to Prof. Herdman before the end of the year for notice, if desirable, in the Annual Report.

IX.—All subscriptions, payments, and other communications relating to finance, should be sent to the Hon. Treasurer. Applications for permission to work at the Station, or for specimens, or any communications in regard to the scientific work should be made to Professor Herdman, F.R.S., University, Liverpool.

MEMORANDA FOR STUDENTS AND OTHERS WORKING AT THE PORT ERIN BIOLOGICAL STATION.

Post-graduate students and others carrying on research will be accommodated in the small work-rooms of the ground floor laboratory and in those on the upper floor of the new research wing. Some of these little rooms have space for two persons who are working together, but researchers who require more space for apparatus or experiments will, so far as the accommodation allows, be given rooms to themselves.

Undergraduate students working as members of a class will occupy the large laboratory on the upper floor or the front museum gallery, and it is very desirable that these students should keep to regular hours of work. As a rule, it is not expected that they should devote the whole of each day to work in the laboratory, but should rather, when tides are suitable, spend a portion at least of either forenoon or afternoon on the sea-shore collecting and observing.

Occasional collecting expeditions are arranged under guidance either on the sea-shore or out at sea, and all undergraduate workers should make a point of taking part in these.

It is desirable that students should also occasionally take plankton gatherings in the bay for examination in the living state, and boats are provided for this purpose at the expense of the Biological Station to a reasonable extent. Students desiring to obtain a boat for such a purpose must apply to the Curator at the Laboratory for a boat voucher. Boats for pleasure trips are not supplied by the Biological Station, but must be provided by those who desire them at their own expense.

Students requiring any apparatus, glass-ware or chemicals from the store-room must apply to the Curator. Although the Committee keep a few microscopes at the Biological Station, these are mainly required for the use of the staff or for general demonstration purposes. Students are therefore strongly advised, especially during University vacations, not to rely upon being able to obtain a suitable microscope, but ought if possible to bring their own instruments.

Students are advised to provide themselves upon arrival with the " Guide to the Aquarium " (price 3d.), and should each also buy a copy of the set of Local Maps (price 2d.) upon which to insert their faunistic records and other notes.

Occasional evening meetings in the Biological Station for lecture and demonstration purposes will be arranged from time to time. Apart from these, it is generally not advisable that students should come back to work in the laboratory in the evening; and in all cases all lights will be put out and doors locked at 10 p.m. When the institution is closed, the key can be obtained, by those who have a valid reason for entering the building, only on personal application to Mr. Chadwick, the Curator, at 3, Rowany Terrace.

REGULATIONS OF THE EDWARD FORBES EXHIBITION.

[Extracted from the *Calendar* of the University of Liverpool for the Session 1915-16, p. 438.]

"EDWARD FORBES EXHIBITION.

"Founded in the year 1915 by Professor W. A. Herdman, D.Sc., F.R.S., to commemorate the late Edward Forbes, the eminent Manx Naturalist (1815-1854), Professor of Natural History in the University of Edinburgh, and a pioneer in Oceanographical research.

The Regulations are as follows :—

(1) The interest of the capital, £100, shall be applied to establish an Exhibition which shall be awarded annually.

(2) The Exhibitioner shall be a post-graduate student of the University of Liverpool, or, in default of such, a post-graduate student of another University, qualified and willing to carry on researches in the Manx seas at the Liverpool Marine Biological Station at Port Erin, in continuation of the Marine Biological work in which Edward Forbes was a pioneer.

(3) Candidates must apply in writing to the Registrar, on or before 1st February.

(4) Nomination to the Exhibition shall be made by the Faculty of Science on the recommendation of the Professor of Zoology.

(5) The plan of work proposed by the Exhibitioner shall be subject to the approval of the Professor of Zoology.

(6) Should no award be made in any year, the income shall be either added to the capital of the fund, or shall be applied in such a way as the Council, on the recommendation of the Faculty of Science, may determine.

(7) The Council shall have power to amend the foregoing Regulations, with the consent of the donor, during his life-time, and afterwards absolutely; provided, however, that the name of Edward Forbes shall always be associated with the Exhibition, and that the capital and interest of the fund shall always be used to promote the study of Marine Biology."

Appendix C.

HON. TREASURER'S STATEMENT.

The list of subscribers and Balance Sheet for 1915 are shown on the following pages. There is a small balance in favour of the Committee, but unfortunately the Subscribers' List is less than previously: moreover, our source of revenue has been curtailed owing to the regrettable conditions in the Isle of Man during the past year, with the result that there have been fewer visitors to the Aquarium, and the sale of Guides has been very small.

The Committee earnestly hope that more subscriptions will be forthcoming from those who appreciate the useful work that is being carried on at Port Erin.

Edwin Thompson,
Hon. Treasurer.

25, Sefton Drive,
Liverpool.

December 16*th*, 1915.

SUBSCRIBERS.

	£	s.	d.
Browne, Edward T., M.A., Anglefield, Berkhamsted, Herts.	1	1	0
Brunner, Mond & Co., Northwich...	1	1	0
Brunner, Rt. Hon. Sir John, Bart., Silverlands, Chertsey	5	0	0
Brunner, J. F. L., M.P., 43, Harrington Gardens, London, S.W.	2	2	0
Brunner, Roscoe, Belmont Hall, Northwich ...	1	1	0
Chandhuri, Dr. B. L., 120, Lower Circular-road, Calcutta	1	1	0
Clubb, Dr. J. A., Public Museums, Liverpool ...	0	10	6
Cole, Prof., University College, Reading	1	1	0
Dale, Sir Alfred, University, Liverpool	1	1	0
Dixon-Nuttall, F. R., J.P., F.R.M.S., Prescot ...	2	2	0
Gibson, Prof. R. J. Harvey, The University, Liverpool	1	1	0
Graveley, F. H., Indian Museum, Calcutta ...	0	10	6
Halls, W. J., 35, Lord-street, Liverpool	1	1	0
Herdman, Prof., F.R.S., University, Liverpool ...	2	2	0
Hewitt, David B., J.P., Northwich	1	1	0
Hickson, Prof., F.R.S., University, Manchester ...	1	1	0
Holt, Dr. Alfred, Dowsefield, Allerton	1	0	0
Holt, Mrs., Sudley, Mossley Hill, Liverpool ...	2	2	0
Isle of Man Natural History Society	2	2	0
Jarmay, Gustav, Hartford, Cheshire	1	1	0
Livingston, Charles, 16, Brunswick-st., Liverpool	1	1	0
Manchester Microscopical Society...	1	1	0
Meade-King, R. R., Tower Buildings, Liverpool...	0	10	0
Mond, R., Sevenoaks, Kent...	5	0	0
Monks, F. W., Warrington...	2	2	0
Mottram, V. H., 256, Lordship-lane, East Dulwich, London	1	1	0
Forward	£39	17	0

	£	s.	d.
Forward... ...	39	17	0
Muspratt, Dr. E. K., Seaforth Hall, Liverpool ...	5	0	0
O'Connell, Dr. J. H., Dunloe, Heathfield-road, Liverpool	1	1	0
Petrie, Sir Charles, Ivy Lodge, Aigburth, Liverpool	1	1	0
Rathbone, Miss May, Backwood, Neston	1	1	0
Rathbone, Mrs., Green Bank, Allerton, Liverpool	2	0	0
Roberts, Mrs. Isaac, Thomery, S. et M., France ...	1	1	0
Robinson, Miss M. E., Holmfield, Aigburth, L'pool	1	0	0
Smith, A. T., 43, Castle-street, Liverpool... ...	1	1	0
Tate, Sir W. H., Woolton, Liverpool	2	2	0
Thompson, Edwin, 25, Sefton Drive, Liverpool ...	1	1	0
Thornely, Miss, Nunclose, Grassendale	0	10	0
Thornely, Miss L. R., Nunclose, Grassendale ...	2	2	0
Toll, J. M., 49, Newsham-drive, Liverpool ...	1	1	0
Walker, Alfred O., Ulcombe Place, Maidstone ...	3	3	0
Ward, Dr. Francis, 20, Park Road, Ipswich ...	2	2	0
Watson, A. T., Tapton-crescent Road, Sheffield ...	1	1	0
Whitley, Edward, The Holt, Linton-road, Oxford	2	2	0
Yates, Harry, 75, Shudehill, Manchester	1	1	0
	£69	7	0
Deduct Subscriptions still unpaid *less* old Subscriptions received	12	10	0
	£56	17	0

Subscriptions for the Hire of "Work-Tables."

	£	s.	d.
Victoria University, Manchester	£10	0	0
University, Liverpool	10	0	0
University, Birmingham	10	0	0
University College, Reading	2	2	0
	£32	2	0
Add old Subscriptions paid	4	4	0
	£36	6	0

THE LIVERPOOL MARINE BIOLOGY COMMITTEE.

Dr. IN ACCOUNT WITH EDWIN THOMPSON, HON. TREASURER. **Cr.**

1915.	£	s.	d.
To Printing and Stationery	16	18	0
,, Boat Hire	5	18	3
,, Books, Apparatus and Supplies at Port Erin Biological Station	18	13	4
,, Postage, Carriage, &c.	2	14	5
,, Salary—Share of Curator's	85	0	0
,, ,, ,, Assistant's	27	6	0
,, Sundries	5	19	10
,, Balance in Hand, December, 1915	13	3	3
	£175	13	1

1915.	£	s.	d.
By Balance in hand, December, 1914	29	18	0
,, Subscriptions and Donations received	56	17	0
,, Amount received from Universities for hire of "Work Tables"	36	6	0
,, Laboratory Fees	2	15	0
,, Interest on British Association (1896) Fund	35	8	4
,, Interest on Investment	2	5	4
,, Sale of Guides and Post Cards	1	2	8
,, ,, Specimens, Bottles, &c,	2	5	3
,, Bank Interest	8	15	6
	£175	13	1

Endowed Invested Fund:—
British Workman's Public House Co. 90 Shares £1 each fully paid.

	£	s.	d.
Memoir Fund—Balance, December, 1914	124	6	0
Sale of Memoirs	23	16	3
Fire Claim	99	0	0
	£247	2	3
Cost of Tubifex Memoir	62	2	2
	£185	0	1

Extension Fund :—Balance, as at December, 1914......£37 4 9

Grants from Board of Agriculture and Fisheries—
Balance December, 1914 .... £275 0 0

EDWIN THOMPSON,
HON. TREASURER.

Audited and found correct,
COOK & LEATHER,
Chartered Accountants.

LIVERPOOL, *December 16th, 1915.*

NOTE ON THE PROSPECTUS OF PROFESSOR EDWARD FORBES' "OINEROMATHIC" CLUB.

By MAY ALLEN, B.A.,
Sub-Librarian in the Faculty of Science,
University of Liverpool.

[Read December 10th, 1915.]

In Professor Herdman's address on " The Life and Work of Edward Forbes," read at the last meeting of the Society, reference was made to the Students' Club, " The Brotherhood of the Magi," formed by Edward Forbes and his friends at the University of Edinburgh in 1835, which had for its symbol a silver triangle, on which was engraved "ΟΙΝΟΣ ΕΡΩΣ ΜΑΘΗΣΙΣ." This reminded me that there had recently been found, slipped into a book in the Departmental Library of Zoology, a two page lithographed circular, which is evidently the prospectus of Forbes' "Oineromathic" Club, and I think it will be of interest to reproduce in Forbes' Centenary Year this literary and scientific curiosity of which it is probable that few, if any, other copies survive.

The book in which the circular was found (Forbes' "Literary Papers," London, 1855) belonged to the late Mr. John Aikin, of Liverpool, who spent the early years of his life in the Isle of Man, and who probably made friends with Forbes when they were school boys together there. This friendship was continued, for in 1838 we hear of Forbes writing from Edinburgh to Mr. Aikin and telling him of the progress of his "Malacologia Monensis," and it was probably about this time that Forbes sent him a copy of the prospectus of the " Oineromathic" Club, which he may subsequently have slipped into the " Literary Papers," where it has been for over 60 years.

The highest aim of Man is the discovery of the Truth; the search after Truth is his noblest occupation. It is more—it is his duty. Every step onwards we take in science and learning tells us how nearly all sciences are connected. There is a deep Philosophy in that connexion yet undeveloped,—a Philosophy of the utmost moment to man—let us seek it out. The world in which we live is a beautiful world, and the Spirit of Omnipotence has given us many pleasures and blessings—shall we not enjoy them? Let us refresh ourselves with them thankfully, whilst we go forth in our search after Truth. We are all brethren, but it has pleased God variously to endow our minds: Some delight in one thing, some in another: Some work for the good of the body, and some for the good of the Soul: Let us all work together in fellowship for our mutual happiness & joy: Wherefore should men quarrel one with another, because they hold different doctrines? Such as seek for Truth in the right spirit sympathize with each other, and however opposite may be their present opinions, revile them not, but assist in their developement knowing however wide apart may seem the paths they have chosen, one goal is aimed at, and if persevering, both must meet in the one wished for Temple. Let those who feel the spirit to develope the Wisdom of Creation, and to act for the good of their fellow men, strong within them, unite together in a bond of fellowship each Brother devoting his time and his energies to the department for which he feels and proves himself best fitted; communicating his knowledge to all, so that all may benefit thereby, casting away selfishness and enforcing precepts of Love: By such means Glory shall accrue to his order, so that it may wax powerful in intellectual strength, and become a mental and a moral safeguard to the World, and a bond of union among all nations. Such is our Brotherhood.

In the subjoined scheme of our objects and principles, the Candidate will find what is required of him: The ties that bind us together are ties of Intellect and Love. Should money ever be wanted for the promotion of the objects we have in view, it must be contributed only as a voluntary gift, and not as a price of admission into our Fraternity.

The Brotherhood of
Friends of Truth
object
the
Search after Truth
by means of

Knowledge

Science
Literature
Art

Fellowship

Qualities of Candidate

Intelligence *Morality* *Philanthrophy*

Activity

Application

Difusion of the Spirit of the Order through Society | *Intellectual* *Material* | *The formation of an Universal Institute divided into Special Academies for each of the branches of Human Knowledge*

By the appeal to all intelligent and moral men to seek after Truth

By the propagation of the Order

Works { *Monthly*, *Annual* }

Publication { *Internal*, *External* }

(1) *The reading of Memoirs in the Academies*

(2) *The establishment of Journals for the publication of such memoirs, &c.*

Duties
of
Brethren

Intellectual

(1) *Propagation of the Order and its Principles*

(2) *Study of Sciences in the triple relation of* { *Observation—Fact*, *Generalization—Law*, *Application—Art* }

Moral

Fraternisation

as extended to all mankind

as developed among the Brethren by { *Physical*, *Intellectual & Moral* } *Succour*

This book, among others, was presented to the University Library in 1906 by the widow of John Aikin.

The first page of the prospectus is headed by the symbol of the Club, which is here reproduced.

In his "Memoir of Edward Forbes" (1861), Wilson says :—"We have seen . . . . . what an affection he [Forbes] had for a trinity of things, and how lovingly from his earliest years he used to sketch the triangular symbol of his native island. This fondness found ample field for its exercise in the organisation of the brotherhood, which, doubtless, owed its form mainly to him. The Order was founded on the ninth day of the third month, its symbol was the triangle, its motto a triad, its ceremonial officers nine, the hour of its meeting three minutes past nine, and so on."

REPORT ON THE INVESTIGATIONS CARRIED ON DURING 1915 IN CONNECTION WITH THE LANCASHIRE SEA-FISHERIES LABORATORY AT THE UNIVERSITY OF LIVERPOOL, AND THE SEA-FISH HATCHERY AT PIEL, NEAR BARROW.

EDITED BY
PROFESSOR W. A. HERDMAN, F.R.S.,
Honorary Director of the Scientific Work.

CONTENTS.

INTRODUCTION.

In this second year of war we naturally find our opportunities for Sea-Fisheries investigation even more restricted, and the results which we have to report upon considerably less, than was the case at the end of 1914. Consequently a shorter report than usual will suffice. Moreover, it is the wish of the Committee—a view with which we most heartily concur—that no unnecessary expense should be incurred either in the work itself or in printing the results, and that

the Annual Report should, for the present year, be issued in this modified form, consisting of a brief statement of the investigations undertaken and of such conclusions arrived at as seem to be worthy of publication—leaving the detailed observations, the tables of statistics, the diagrams, curves and charts with which these reports have usually been illustrated to be produced on some future occasion, when normal conditions of scientific fisheries work shall have been resumed in our District.

STAFF.

Our scientific staff has, naturally, been reduced—those who were of military age having left us for work connected with the war. Mr. W. Riddell is enrolled in the corps of expert bacteriologists who are investigating the cases of dysentery, typhoid and other similar diseases of the soldiers in military hospitals. His work, for the present, lies in the Hospital and the Laboratory of the Liverpool School of Tropical Diseases, but it is probable that he will eventually be sent abroad.

Mr. T. Hampson, after being rejected on medical grounds, enlisted as an hospital orderly; but on account of his knowledge of laboratory methods and of the preparation of bacteriological media he was transferred from Fazakerley Hospital to the Pathological Laboratory of the University to help in the preparation of the necessary materials for the investigation of the hospital cases.

Both these Fisheries Assistants, then, may be regarded as having been appointed to war work for which their previous training in our laboratory rendered them peculiarly suitable. It is eminently desirable that on the conclusion of the war they should both resume their posts on the Committee's scientific staff.

The members of the scientific staff who remain have had their time fully occupied with useful work, as will be seen from the notes which follow.

Work at the Piel Laboratory.

It was found to be impossible, under the existing war conditions in the District, to carry on any fish-hatching at Piel in the spring of 1915, and it will be the same again during the present season; but, as Mr. Scott's report given below shows, the practical classes for fishermen were successfully conducted, in a somewhat modified form—which may or may not have to be followed, if classes are held this summer, according as circumstances may dictate. Mr. Scott also gives an interesting account of the important sprat fishery which has recently been developed in Morecambe Bay, and which seems to be a notable example of one of the minor fishing industries which might be promoted in our coastal waters.

Herring Work.

Our share in the scheme of investigation of the races of herrings found off the British coasts, drawn up by the Board of Agriculture and Fisheries a few years ago, has been entrusted to Mr. Riddell, and his reports upon his work during the years 1913 and 1914 will be found in our last two Annual Reports. The investigation has become a much more extensive one than was contemplated at first, a considerable number of observations on each fish have had to be made and recorded, and the amount of data to be worked up was large. A considerable amount of Mr. Riddell's time during the past year

has been occupied in an analysis of such data, both his own and those of previous observers, and the results will be found in his article on the subject in this report. His object has been to investigate the extent to which statistical methods can be used to compare the various samples already examined, and to estimate their reliability. This necessitates the separate examination and mathematical investigation of the data obtained from each sample, and then comparison with each other, in many cases a difficult and tedious operation.

During the past year war conditions and adverse weather have prevented us from obtaining adequate samples from the herring fisheries in the Irish Sea. During the summer fishery off the South of the Isle of Man one good sample was obtained from Port Erin, and this was examined and recorded. Arrangements had been made to procure further samples from this fishery, but these broke down on account of the unfavourable weather. From the winter fishery off the Welsh coast only two small samples could be obtained, and these have been examined, and the records, along with those of previous years, are retained for further consideration when larger and more numerous samples can be secured.

Mr. Riddell's investigation, so far as it goes, tends to show that more than one race of herrings enter the Irish Sea, and that those of the summer fishery off the South of the Isle of Man differ in character from those of the winter fishery off the Welsh coast. It is clear, however, that the examination of further samples and additional research is necessary before these important herring questions can be considered definitely settled. It must be remembered that similar work is being carried out by other investigating authorities for the Board of Agriculture and Fisheries, and that all the results obtained, both here and elsewhere, will have to be collated and compared in order to work out a complete and consistent history of the herring fisheries in British seas during the year.

The Liverpool Laboratory.

Dr. Johnstone has been frequently engaged on and off during the year, both on the shore and in the laboratory, in working out important questions in connection with schemes for the improvement of mussel cultivation on both the Lancashire and the Welsh coasts, as will appear from his article on the subject in this report.

I drew attention last year to the opportunity, which the interruption of our scheme of work at sea gave, for a concentration of effort upon improving the fishing industries of the inshore waters and the cultivation of sea beaches. It is obvious that when, on the conclusion of war, many men return to work along our coasts any increase of employment in connection with local fishing industries will be of direct and immediate advantage to the country. The extension of shell-fish cultivation, for example, will not only add to employment, but will increase the food and bait supplies of the country, and may lead to the establishment of permanent industries of a profitable nature. Much of the Committee's scientific work in the past has been directed towards this useful end, and they may fairly be said to have established a claim to be regarded as pioneers in both the cultivation and the purification of their shell-fish beds.

Although the Development Commission did not see fit to give a grant towards the scheme for transplanting, fattening and then purifying mussels, which we laid before them last year, our Committee has continued the work so far as opportunity offered, and much of Dr. Johnstone's time throughout the year has been occupied in the necessary topographical inspections of the shell-fish beds and the subsequent bacteriological investigations in the laboratory. It is to be hoped that nothing will be allowed to interfere with this work, and that whenever possible further funds will be devoted towards the promotion of schemes which

seem desirable, if not indeed essential, from the point of view of the industry and of public health alike.

The two remaining articles by Dr. Johnstone, dealing with plaice fisheries in the district, scarcely require further remark. They are both the natural continuation of work upon the sizes of the plaice in various parts of the district and at different times, and their migrations in relation to the recognised fisheries, which Dr. Johnstone has been engaged upon for some years, and upon which he has written in previous reports. I am sure that this work when carefully examined will commend itself to the Committee as giving the kind of data upon which fisheries regulations and bye-laws of the future must be based.

Plankton Investigations.

Although the collection of plankton samples from the open sea has ceased, I have found it possible by obtaining a special permit from the authorities to have weekly samples taken across the mouth of Port Erin Bay at the South end of the Isle of Man, which is about as central and typical a locality as one could find in the Irish Sea. With the expert help of Mr. A. Scott and Miss H. M. Lewis these samples have been worked up in detail and we have in hand all the data for a further instalment of our "Intensive Study" of the microscopic life of the surface of the sea throughout the year. We give a summary of this in a short article at p. 133.

Need of Scientific Investigation.

Many "Advisory" and other Committees, both in connection with the great Government Departments and also amongst the leading Scientific Societies, are at present engaged in deliberations in connection with the great war we are waging, not merely with immediate and pressing war problems, but

also with the later and possibly equally important after-war questions, which are bound to arise affecting the prosperity of the country and the maintenance of the Empire.

A large number of these matters turn upon the application of scientific knowledge and scientific methods to various industries, and amongst these not the least important are those concerned with the allied subjects of agriculture and aquiculture or the scientific regulation and cultivation of our fisheries. I think it appropriate under these circumstances to add a few words on the general question of Science in relation to the industries, a matter on which it is of vital importance that all thinking men should be correctly informed and prepared to act with wisdom and promptitude. National efficiency, both in war and in commerce, depends to a very great extent upon the degree in which scientific results and methods are appreciated by the people and scientific investigation is promoted by the Government and other Administrative Authorities.

It is, I believe, recognised that, with the view of making a rapid recovery from the effects of the war, amongst other things agriculture and allied industries must be promoted, and it must be seen to that no good land is wasted, that none is applied to the wrong purpose, and that the most suitable treatment to ensure the best results is given to each area. In fact, a more systematic study and more extensive cultivation of the land must be made. In quite a similar way and for no less important reasons the harvest of the sea must be promoted, the fisheries must be continuously investigated, and such cultivation as is possible must be applied to our barren shores. All this is one of the natural applications of Biological Science.

Dr. C. W. Eliot (Past President of Harvard University), in his recent Presidential Address to the American Association for the Advancement of Science, entitled " The Fruits, Prospects

and Lessons of Recent Biological Research," in considering how advance of knowledge has promoted the general welfare of mankind, comes to the conclusion that "during the past one hundred years it is biological science that has contributed most to the well-being of humanity." This is the thesis which he develops in detail with many illustrative examples showing the application of purely scientific biological investigations in the laboratory to agriculture and allied industries, protection from animal pests, public health, preventive medicine, sanitation and bacteriology, the increase, improvement and preservation of food matters, and their protection from infection. "All these activities have been completely dependent on applied biology for their methods and processes, and have changed and developed rapidly with the progress of that science. Taken together they constitute an immense contribution to human welfare, present and future."

Finally, Dr. Eliot makes an important point in his statement that "the long series of successful applications of biological science illustrates strikingly the impossibility of drawing any fixed line of demarcation between pure and applied science, or of establishing an invariable precedence for one over the other. Sometimes an application is suddenly made of one fragment of an accumulation of knowledge which men of science have made without thought of any application, and sometimes a bit of knowledge successfully applied stimulates purely scientific workers to enter and ransack the field from which the bit came . . No mortal can tell how soon a practical application of a scientific truth, which seems pure in the sense that it has no present application, may be discovered; and on the other hand innumerable applications are nowadays made of truths which five years or fifty years ago seemed as remote from all human interests as the observation attributed to Thales, that a bit of amber rubbed with a piece of silk would repel pith balls suspended

by fine filaments. Yet all magnetism and electricity with their infinite applications hark back to this experiment by Thales and to Galvani's observation of twitchings in a frog's legs."

In the great industrial conflict which certainly lies before us in the years to come, this country will need all the help it can get from University laboratories and other investigating institutions. Success will depend largely upon continuous scientific investigation and the best industrial application of the results obtained. We know that our enemies are already making preparations for this. It will be fatal if we are less prepared and less fully equipped for the work. Science alone can prevail against science. It is reported that a whole army of scientific men have been set to work in Germany to make an exhaustive study of the industrial problems which are sure to arise after the war, with a view to adopting measures to ward off the dangers which may menace the Central Powers. The industrial difficulties and dangers menace us equally, and it would be a suicidal policy to do anything that might reduce our scientific efficiency in the coming period of stress. As Sir William Mather has recently said, " this is not the time to close the doors of laboratories in which provision is being made for the industrial conflict which must come after victory has been achieved. Provision for the present and preparation for the future can be secured only by the strenuous efforts of those engaged in teaching and research at our highest centres of learning ; and it is to their continuous work that we must look both to replace the wastage of promising investigators caused by the war and to train original workers upon whom we must rely for further advance. Any step which would tend to diminish the efficiency, or increase the financial difficulties of our University institutions would seriously, if not irreparably, jeopardise the future welfare of this country."

After the war it will for some time probably be just as important as it is now to prevent money from leaving the country, and with a view to this, as well as for other reasons which I have stated, it is obviously desirable that all home productivity should be organised and stimulated. The minor fishing industries along our shores naturally occur as one step in this direction, and the economic need for developing these deserving industries seems urgent.

I desire, therefore, to submit to the Committee the paramount importance, in the future interests of their fishing industries, of (1) maintaining for the present all such scientific investigations as may still be in any way possible, and (2) restoring as soon as may be practicable after the conclusion of the war the scientific staff and equipment to its former strength and state of efficiency, in order that the Committee's programme of investigations at sea, under the Development Commission, and other important work that was in progress may be resumed before the break in the continuity of the observations becomes too serious.

W. A. HERDMAN.

FISHERIES LABORATORY,
UNIVERSITY OF LIVERPOOL,
February 14*th*, 1916.

REPORT ON THE WORK AT PIEL.

By Andrew Scott, A.L.S.

I. Classes at Piel.

The classes for fishermen in the spring of 1915 required some re-arrangement because of war conditions in the district. Most of the younger deep-sea fishermen sailing out of Fleetwood had joined the steam trawlers taken over by the Admiralty for mine-sweeping and other naval duties. It was therefore only necessary to arrange for one class in the combined course of Biology and Navigation, and this was extended to three weeks, beginning on March 8th. The results were quite satisfactory, and there is no doubt that the extra week proved most useful. The second class, for in-shore fishermen, was attended by fifteen men, including four sent by the County Borough of Southport and two by the County Borough of Blackpool. It was held during the period 26th April to 7th May.

The Barrow Education Committee organised an evening class in Nature Study for school teachers, on similar lines to those held in former years. Ten teachers from the schools at Barrow attended and went through the elementary course of instruction.

Mr. A. Harris, H.M. Inspector of Evening Schools, Dr. Jenkins, Sea-Fisheries Superintendent, and Mr. A. Hawcridge, Director of Education, Barrow-in-Furness, visited the classes and inspected the work that was going on.

Here follow the names of the fishermen students who attended the two classes in 1915 :—

(1) Biology and Navigation—Ernest Batten, Joseph Cromwell, James Leadbetter, Nicholas Leadbetter, Lawrence Moss, Alexander Pilkington, Edward Salthouse, Jeffrey Tomlinson, William Wade, Jeffrey Wright, Peter Wright (1),

Peter Wright (2), Peter Wright (3) and William Wright (all of Fleetwood).

(2) Biology only—Frederick Davies, Bolton-le-Sands; Walter Mayor, Morecambe; Wilfred Woodhouse, Morecambe; W. Butler, Junior, Glasson Dock; Stephen Ainsworth, Fleetwood; Jeffrey Ball, Fleetwood; Jeffrey Wright, Fleetwood; J. R. Wright, Fleetwood; F. Cartmell, Blackpool; J. T. Fish, Blackpool; Jeffrey Abram (Bens), Banks; Daniel Robinson, Southport; Peter Sutton, Southport; William Wright (Bulliver), Southport; and William Wright, Southport.

II. Fish Hatching.

The military restrictions in connection with the defence of Barrow, and the possibility that the tank-house might be required for housing men engaged in outpost duty at Piel, interrupted the hatching operations in 1915. The men are now accommodated in huts, but the restrictions still prevail. Fishing is prohibited in Barrow Channel, but it would have been possible to collect adult flounders in the estuary of the Lune or the Wyre for hatching work in 1916. There is always a certain amount of danger in bringing live fish across the bay in the cutter in winter, and as it would also have been difficult to furnish the authorities with the precise time of arrival, the landings might have been delayed. For these reasons it was decided that it was inadvisable to resume hatching operations while the present restrictions remain in force.

III. Distribution of Fish Eggs in the Plankton.

The only sources of information relating to the distribution of fish eggs in the central area were again this year the samples of plankton collected bi-weekly in Port Erin Bay and immediately outside. There is little to add to the report published

last year that cannot wait till a more convenient time. It may be worth while to note, however, that the duration of the spawning period of any species of fish can be fixed only approximately from the occurrence of the eggs in the plankton. Actual periodic examination of the condition of the fish should also be made when possible. For instance, our records from examination of plankton samples show that sprat eggs may be found floating at the surface of the sea from the beginning of April till the middle of September; while the examination of the sprats collected during the winter fishery at Morecambe indicates that spawning may take place very early in March.

IV. Morecambe Winter Sprat Fishery.

This fishery is practically a new one. It is only some three years since its value began to be recognised by the fishermen and its development attempted. Much of the credit for the success that has attended its gradual progress is due to one of the local men. He was amongst the first to recognise the economic possibilities and visited various sprat and "whitebait" fisheries on the east coast in order to inspect the methods employed in catching the fish. He also endeavoured to find markets for the Morecambe fish and was fairly successful. Previous to the war good prices were obtained for the smaller fish which were sold in the London markets as "whitebait," but this trade has almost ceased now. There is a pretty steady demand for the fish elsewhere in connection with preserving purposes, and considerable quantities of fresh Morecambe sprats are sold in the fishmongers' shops in Lancashire. The number of half-decked and open fishing boats engaged in the fishery is gradually increasing. As many as twenty-five boats were employed in one day during the maximum of the 1915-16 fishery.

The method introduced into Morecambe for catching

sprats is the "stow-net" in a slightly modified form to suit the conditions prevailing in the adjacent channels. The net is built up of two kinds of netting. The front portion is ordinary fish trawl net of six inch mesh; the remainder is shrimp net, with the usual mesh employed in the district. This combined net is attached by the back and front to two strong hardwood beams. The beams separate when the net is lowered into the sea and form a rectangular opening. The beams are provided with bridles, and these are shackled into a swivel from which a chain or strong rope leads to a fairly heavy anchor. The net is thus anchored to the bottom when in use. Another chain between the boat and the swivel keeps the boat anchored to the fishing gear. The upper beam is furnished with ropes at each end, by means of which the fishermen regulate the depth the gear is lowered to when at work. A rope is attached to the middle of the lower beam, passes through a thimble in the upper one, and thence to the boat. This enables the fishermen to shut the net when it has filled with fish, by pulling the lower beam up close to the top one. The lower hardwood beam in most of the "stow-nets" used at Morecambe is replaced by one of iron. This is usually a long piece of galvanised piping about three inches in diameter, which the men buy from the ship-breakers at the old harbour. It is not an uncommon occurrence to see a boat returning with the lower beam broken by the strain from the weight of the catch, when it has not been replaced by an iron one. A "sweep-rope" is fixed to the beginning of the tail of the net to draw it alongside the boat. Further back, about a yard from the tail-end, another rope known as a "bowler" is placed, and is used to constrict the net when the catch is being removed.

When the fishermen arrive at the place where the fish are expected, the net anchor is dropped overboard, then the anchoring chain between the boat and bridles; the beams

follow, and finally the net is cleared away. As the shrimp-net part fills with living fish it rises to the surface. A close watch is kept on the rising net, and as soon as it is full the lower beam is hauled up against the top one. If the critical point is missed and the fish allowed to die the net sinks to the bottom. It may then be impossible to close the entrance, and the weight of the fish, combined with the force of the current, is so great that the net may burst, be torn out of the beams, or the whole gear broken away from the anchor drag chain. When such accidents happen most of the catch is generally lost. If the fishermen are successful in closing the opening, they heave up the chain between the boat and the swivel to get hold of the bridles so that the beams may be drawn alongside. The tail-end is then brought to the side of the boat with the "sweep-rope" and the catch removed. The "bowler" is used when the fish are to be packed into boxes or bags aboard the boat. The part enclosed by the "bowler" contains enough fish to fill two half-hundredweight boxes. The "bowler" is slackened and the space allowed to fill with fish from the upper part of the tail-end. It is then tightened, the end unlaced and the fish run into the boxes. This operation is repeated again and again until the whole of the catch is dealt with. When the entire catch has been removed, the tail-end is laced up and slackened away, the beams and bridles dropped to the bottom, and the anchor-chain paid out. The fishing is practically continuous so long as the tide and other conditions remain favourable. The accumulated catch is sent ashore from time to time in a small boat.

The winter sprat fishery generally begins in October, and may last till the beginning of March. Considerable quantities are captured in the baulks in the estuary of the Lune and at the west end of Morecambe, occasionally even in September. The invasion apparently sets in from the south

in the autumn, and soon extends over the whole of Morecambe Bay. The fish become abundant off Morecambe towards the end of November. They may then even extend as far as Grange and across the Bay to Roosebeck. Sprats are sometimes caught in the ordinary stake-nets at the latter place when the meshes become choked with débris. There is usually a decided indication of a slackening in the invasion in the Morecambe area by the end of January; after that, the catches become smaller and the fishery diminishes in value. Twenty-five boats were engaged during the maximum period of the fishery in 1915-16, and fully seventy tons were landed in one day. The money value of this catch to the fishermen was fully £300. Fresh Morecambe sprats were sold in the fishmongers' shops in Barrow at the same time at threepence per pound. A ton of sprats contains on an average 130,000 fish. In the course of a day's fishing, therefore, the huge total of nine millions of sprats may be captured without making any appreciable difference to the fishery. The sprats are usually sent to the market just as they are captured. If there is a large proportion of the smaller sizes, the catches are riddled, and the small fish that pass through are sold as "whitebait."

Samples of the catches were sent for examination by Mr. Edward Gardner, the Assistant Bailiff at Morecambe. Personal visits were also made from time to time and samples collected. The sprats caught during the season 1915-16 were all in fine condition. No trace of recognisable food was observed in the stomachs of any of the samples collected. The whole of the alimentary canal was usually filled with fatty mucus only. The stomachs of the few young herring taken along with the sprats generally contained small *Mysis*. The weights of the individual fish were also determined, and it was found that an appreciable difference sometimes existed between fish of exactly the same length. This difference occasionally

amounted to as much as a gramme and a half. Adult sprats, measuring 134 millimetres, practically $5\frac{1}{4}$ inches in length, with the reproductive organs half developed, usually weighed 19·2 grammes. Young sprats, half that length, only weighed 1·6 grammes, or just one-twelfth the weight of the adult. Estimations of the oil in the muscle substance were made by means of the Soxhlet apparatus, in the manner described by Dr. Johnstone on page 154 of the report for 1914. The percentage of oil amounted to 9·4, which is practically the same as that found in immature sprats collected in May.

The sprat fishery exhibits a noticeable falling off in February, and by March it may become so unproductive that it is abandoned. It occasionally happens, however, that the invasion of the adults is followed by wandering shoals of young clupeoids, chiefly herring, which may prolong the fishery in a spasmodic manner throughout the summer. The departure of the adults is due to natural causes. The reproductive organs are advancing towards maturity when the fish arrive in the area. Development continues—and by the end of February the organs are practically mature. The fish then begin to leave the shallow coastal areas to spawn in the deeper water where the specific gravity is higher. The eggs are buoyant and float near the surface. The larva hatches in less than a week. If the spawning took place close in-shore, where the adults pass the winter, many of the eggs and larvae would be destroyed through stranding.

During the winter fishery practically the whole of the clupeoids sent to the market are sprats, from half grown to the adult state. The range in length varies from $2\frac{1}{4}$ to $5\frac{3}{4}$ inches. Young herring are seldom met with in the winter catches. None of the samples contained more than 2 per cent. These proportions are quite reversed in the summer. A sample taken at the end of July contained 86 per cent. of young herring, and only 14 per cent. of young sprats. The herring

measured $2\frac{1}{2}$ to $4\frac{3}{4}$ inches in length. None of the sprats exceeded 3 inches. The summer clupeoids may be regarded as typical "whitebait." The detailed results of the examination of samples will be published in tabular form later on, and, in the meantime, it is proposed to continue the investigation.

Sprat and "whitebait" fishing is not provided for in the present bye-laws of the Committee, and there is no fixed close time. Permits are required to use the small-meshed nets necessary to catch the fish. These are readily granted by Dr. Jenkins, the Superintendent, and the conditions attached to their use are loyally observed by the fishermen.

V. "Whitebait" Collected in Menai Strait.

This investigation has been continued. The material has not been so plentiful as in 1914, nor could it be collected from the weir at Gorad Coch. The samples sent by Capt. R. Jones, during 1915, were taken in the Penrhyn fish weir, near Bangor. The fish are probably quite representative of the shoals which reach the Swillies, and would eventually be caught at Gorad Coch. There is nothing of importance to add to last year's report. The tables giving the detailed measurements of the samples will be published later.

VI. Sea Gulls and Shell-Fish Beds.

One hears complaints from cockle fishers from time to time concerning the amount of damage done to shell-fish beds by the ravages of sea gulls. The stake-net fishermen also say that their fish are frequently carried away by these birds, or are so much damaged that they are unfit for the market. One of the former lighthouse keepers at Walney tells me that it is quite a common sight, during the breeding season, to see the parent gulls returning from the direction

of Ulverston Channel to the gulleries at the south end of Walney, with silvery fish projecting from their beaks. It is urged by the fishermen that the protection afforded under the Wild Birds Protection Acts has led to an enormous increase in the number of gulls. This has been accompanied by a corresponding increase in the destruction of shell-fish and of fish. There is no doubt that the gulls do eat the cockles, as the excreta and regurgitated stomach contents seen in the vicinity of a cockle bed prove. Partially destroyed fish can often be seen in the stake-nets one visits at low-water. It is quite possible that the fishermen are a good deal to blame by leaving unwanted cockles lying on the sand, and by not fishing the stake-nets as soon as they dry.

In the Quarterly Report to the Scientific Sub-Committee last November (see below, p. 157), I gave some evidence as to the shell-fish food of the gulls on the Bardsea Mussel bed and the Flookburgh Cockle bed.

It must be remembered, however, that sea gulls are not entirely useless to man in general, although the fishermen may regard them as enemies. Their wholesale destruction, which is frequently suggested by the in-shore fishermen, might easily end in the cure being worse than the disease. It is intended to follow up this investigation, which can only be done during settled and fairly dry weather, to see how far the decreased activity in fishing the cockle beds diminishes the destructive action of the gulls.

LEGAL SIZE-LIMITS FOR PLAICE.

By James Johnstone, D.Sc.

A considerable amount of work has been done lately on the plaice statistics collected for the Committee during the last seven years, since it is probable that these data may be required in the future, in connection with proposals for legal size-limits for plaice.

In September, 1913, the International Council for Fishery Investigations recommended to the various Governments interested in the North Sea Fisheries that legal size-limits for plaice should be established. The sizes proposed were :— 1st October to 31st March, 20 centimetres (about $7\frac{3}{4}$ inches); 1st April to 30th September, 22 centimetres (about $8\frac{3}{4}$ inches). It was recommended that it be illegal to land plaice which were smaller than these sizes.

The decision of the International Council was taken as the result of the consideration of experimental fishing operations carried out in the North Sea, and of very extensive measurements of plaice landed at English ports by steam and sailing trawlers.

Inasmuch as these figures are of little assistance in estimating the effect of a possible extension of legal size-limits for plaice to the West Coast, it was suggested by an Inspector of the Board of Agriculture and Fisheries that the data obtained by the Lancashire and Western Sea Fisheries Committee be examined.

The data available.

Very numerous hauls with trawl-nets of 6 in. mesh have been made by the steamer and sailing vessels of the Committee. On all occasions the plaice caught were measured, and numerous

samples were sent to the Laboratory at Liverpool. There are large series of figures for the following localities :—

(1) The summer plaice fishery in the Irish Sea between Blackpool and Liverpool Bar.

(2) The summer and autumn plaice fishery outside the Mersey Estuary.

(3) The winter plaice fishery off the coast of Carnarvon and Anglesey.

There are also data for Morecambe Bay, Carnarvon and Cardigan Bays. These series are not so complete as those mentioned above, but are probably sufficient.

Other data necessary.

Comparatively little is known as to the catching power of stake nets. The method is of importance in the Lancashire and Western District, and statistics should be obtained.

The results now available.

Tables and charts have been prepared with respect to the three fisheries noted above. The crude statistics have been corrected and theoretical series (most probable series) have been calculated to replace the observation series. From these corrected statistics and charts the percentages of plaice over and less than any specified size, or between any two specified sizes, can be obtained, and the probable errors to be expected in applying such data for the purpose of legislation can also be obtained.

The effect of the International proposals on Lancashire Fisheries.

If these were adopted it would become illegal to land plaice less than 20 centimetres ($7\frac{3}{4}$ inches) during the winter months. This would lead to the rejection (returning to the

sea after capture) of a proportion of all catches varying from 70 to 21 per cent. according to the fishing ground and month.

It would also be illegal to land plaice of less than 22 centimetres (about $8\frac{3}{4}$ inches) during the summer months. This would mean the rejection of from 90 to 51 per cent. of the plaice caught according to the ground and month.

The averages for the whole seasons would be :—

	Under 20 cms.	Under 22 cms.
Blackpool to Liverpool Bar ...	**42**%	**65**%
Off Mersey Estuary	**52**%	**77**%
Beaumaris and Red Wharf Bays	**36**%	**50%**

These are the effects to be expected from the imposition of the International plaice-limits on the Lancashire and Welsh trawl-fisheries.

The stake-net fisheries would be even more adversely affected, and the winter size-limits would probably destroy these fisheries altogether. It would often be quite impracticable to return undersized plaice caught in a stake-net alive to the sea, so that the total abolition of these methods of fishing would probably be preferable to the imposition of size-limits of 20 and 22 centimetres.

In considering the effect of legal size-limits upon the Irish Sea plaice fisheries as a whole, the migrations of the fish in local waters must be considered. This is discussed in the following article.

THE MIGRATIONS OF PLAICE IN THE IRISH SEA.

By James Johnstone, D.Sc.

The last plaice-marking experiments were made at the end of 1913, so that all the recaptures likely to be made must now have been reported. A summary has been prepared, and as this has some important bearings on the question of legal size-limits an abstract of the results is now presented.

All the experiments made in the summer and autumn of the years 1905-1913 in the " Nelson Buoy Area " have been combined. Most of these experiments were made during the months June and July, one was made in September and one in October. About 1,100 plaice were marked and liberated, and the positions of recapture of about 280 of these fish have been traced. This is the material dealt with in the meantime.

A series of charts have been prepared showing the positions of recapture, and the sizes of all the fish caught during each month from June to December, for the periods January to April, and May to September of the year following that of the experiment. These charts show as clearly as possible the general movement of the plaice shoals inhabiting the area of sea within the 20-fathom line off the coast of Lancashire.

A further synoptical chart has been prepared showing the migrations. Contour lines have been drawn round the positions of recapture of all the fishes caught in June-July, in August, in September-October, in November-December, in January-April, and in May-September (the two latter periods applying to the year after that of the liberation of the fish). These contour lines represent successive " fronts " occupied by the moving shoal of fish during the periods mentioned.

The evidence is very clear and convincing. It is not given here in the meantime, but I have prepared an abstract of the main conclusions.

(1) The Plaice population at the beginning of Summer.

In June this is made up as follows :—

13 to 16 centimetres long, about	1 %	of all the plaice taken in a six-inch mesh trawl-net.
16 ,, 18 ,, ,, ,,	15 %	
18 ,, 21 ,, ,, ,,	50 %	
21 ,, 23 ,, ,, ,,	15 %	
23 ,, 33 ,, ,, ,,	19 %	

These plaice have been spawned to the north-east of the Isle of Man, or in St. George's Channel. The eggs and larvae drift into shallow water and are reared there. The plaice inhabit the shallow-water nurseries in the Bays and Estuaries until they are about 20 cms. in length.

(2) Age at which Migration begins.

This is over two and less than three years as a rule. Plaice less than 20 cms. in length hardly migrate at all, that is, they do not move outside the 5-fathom line. Of 1,100 plaice liberated in these experiments

5 % were less than 19 cms. long
13 % ,, 20 ,,
34 % ,, 21 ,,
while 50 % were from 20 to 23 cms. long.

Of the 280 plaice recaptured

0 % were less than 19 cms. long
1 % ,, 20 ,,
9 % ,, 21 ,,
while 50 % were from 21 to 25 cms. long.

Even in the month of liberation and that immediately after, that is, before the fish had had time to grow, hardly any plaice, of those marked which were less than 20 cms. long, were recaptured. The small plaice up to 20 cms. long off the Lancashire Coast *are a practically stationary population* partially hibernating in the winter months.

(3) The Spring and Summer Migration.

This is from inside and about the 5-fathoms line, into deeper water out at sea. The plaice which are over 20 cms. long travel almost due west out to the 20-fathom line, and none go beyond this. Most of them are recaptured between the 10- and 20-fathom lines. About 50 per cent. of the recaptured fish are between $22\frac{1}{2}$ and 26 cms. in length: 30 fish were recaptured.

(4) The Autumn Migration.

This begins in August. The plaice begin to move back again in-shore toward shallow water. Those plaice recaptured in August were all taken from an area extending from about Morecambe Bay Light Vessel, on the north, to about Liverpool North-west Light Vessel on the south. The western boundary of this area is about half-way between the 10- and 20-fathom lines, and its eastern boundary is about half-way between the 10- and 5-fathom lines. Of the plaice recaptured in August inside this area 50 per cent. were between 22 and $24\frac{1}{2}$ cms. in length, that is, the fish were rather smaller than the June-July caught ones, a decrease probably due to fishing-out of the larger individuals: 28 plaice were recaptured.

September-October.

The majority of the plaice are still migrating in-shore, to the eastward, during these months. About 70 fish were recaptured, and about half of these were still found inside the area occupied in August, but much further to the east. About half had moved to well in-shore from this area, so that the "front" now held is just inside the 5-fathom line. In addition to this easterly migration into shallower waters there are also indications of four other lines of migration.

(5) The Winter Migrations.

These other four lines of winter migration are :—

1. Into Morecambe Bay.
2. Into the Estuaries of the Mersey and Dee.
3. Into "Channel Course" and the Red Wharf Bay Area.
4. Towards the Isle of Man.

About 70 fish were recaptured during the months of November-December. Considering the sizes of these plaice we arrive at some very interesting results.

1. The majority of the smaller fish migrate in-shore into the shallow waters of the Ribble Estuary, and are caught as close to the land (in stake-nets, shank-nets, and trawl-nets) as fishing can be carried on.

   A smaller proportion of fish of the same range of sizes migrate into Morecambe Bay, *round the north part of the Bay*, and are caught in very shallow water.

   An equally small proportion migrate into the Dee and Mersey.

2. The larger plaice migrate in November-December to the west, along "Channel Course," that is the track of vessels approaching Liverpool from Point Lynas. These fish are mostly caught off the coast of North Wales between Great Orme's Head and Anglesey, and mostly between the 10- and 20-fathom lines.

3. The largest plaice of all migrate to the north-west towards the North-east Coast of Isle of Man, and are caught mainly on the Great Bank to the east of Bahama Light Vessel where the water is less than ten fathoms in depth.

January and February.

The in-shore migration to the coasts of Lancashire and Cheshire continues. So also does the off-shore migration to the north-east of Isle of Man. But the westerly migration into North Wales area ceases very suddenly in January.

(6) Length of Fish, and Migration paths.

We must now note the characteristic sizes of the plaice taking part in these migrations. The plaice that migrate into the Lancashire and Cheshire shallow waters in the winter are "small," that is, 50 per cent. are between $21\frac{1}{2}$ and 25 cms.

The fish that migrate into the North Wales area deeper waters may be called "medium": 50 per cent. of them are between 23 and 26 cms.

The fish that migrate towards the north-east of Isle of Man are "large": 50 per cent. are between 25 and $28\frac{1}{2}$ cms.

(7) Seasonal, Feeding and Spawning Migrations.

These are the kinds of migration exhibited by plaice in the Lancashire off-shore area.

Seasonal migrations are undoubtedly determined by the change of temperature of the sea-water during the year. It would take too long to elaborate this point, which is, however, quite clear and certain from our accumulated observations.

Feeding migrations are brought about by local aggregations of food on the sea bottom, as, for instance, the formation of a bed of growing mussels (see the instance given by Scott in the Quarterly Report for October, 1913). These are not migrations in the strict sense, but rather local and temporary aggregations of plaice.

Spawning migrations have little importance in the Lancashire area, as the plaice are mostly immature. The larger fish that migrate towards the north-east of Isle of Man do so in order to spawn there. The larger plaice found off the coasts of North Wales in the months of November and

December are sexually mature fish, but they do not spawn there. The spawning grounds of these plaice are further to the south in St. George's Channel.

(8) The question of Legal Size-limits.

Data for the discussion of the effect of these on the local fisheries have already been referred to in the previous article in this Report. But these marked fish experiments give us some notion of the extent to which the "deep sea" plaice fisheries may be expected to benefit by a restriction of the size of capture of plaice in in-shore waters.

Little over 3 per cent. of the 1,160 plaice marked on the Lancashire nursery grounds have been observed to migrate permanently into the deep water off-shore. Less than 1 per cent. of these marked plaice have been recovered from outside the eastern part of the Irish Sea. These data do not give much assurance that the result of protecting the small plaice in-shore will lead to a notable increase in the numbers of large plaice off-shore. The data are very few, but I know of no others relevant to the legislative question involved.

It is well known that large plaice were at one time much more abundant on the banks off the North-east Coast of Isle of Man than they are nowadays. These banks are undoubtedly fed by small plaice from the shallow water nurseries. The reduction of the stock of large plaice on them is to be traced to intense fishing, mainly by steam-trawlers, during modern times. It cannot be denied that this stock of large plaice might be increased by favouring the off-shore migration by restricting the capture of small plaice in-shore—to an unknown but certainly small extent. Such restrictive legislation would, in all probability, greatly reduce the catch of small plaice in-shore, and slightly increase the catch of medium and large plaice off-shore, and the economic question to be considered is this :—*Is it worth while?*

HERRING INVESTIGATIONS.

By W. Riddell, M.A.

The following is a brief account of an attempt to apply Professor Karl Pearson's "goodness of fit" method to the question of herring races. Being given two samples, which may be either of the same or of different populations, this method enables us to find the probability that as great, or greater, divergence would be found between two random samples drawn from one population. In other words, it gives us an estimate of the probability that the two samples belong to one population.*

The first investigations into the question of herring races in this country are due to Matthews.† He paid attention mainly to the distinction between winter and summer fish, and came to the conclusion that there was no real racial distinction between the two. Matthews' figures, or rather his method of employing them, have been criticised by Heincke,‡ who claims that they give as much proof of distinction between the two races as any of Heincke's own.

By testing Matthews' tables by the present method, we find that Heincke's contention is justified. Matthews, unfortunately, only published his tables in percentages of the total number of fish, and we have not either his actual measurements or the total number of fish dealt with in the tables.

But taking his figures as they stand, we find the following results :—

* Pearson, *Phil. Mag.*, L, p. 157 ; *Biometrika*, VIII, p. 250, X, p. 85.

† *Ann. Rep. Fish. Bd., Scotland*, IV, 1884 (1885), p. 61 ; V, 1886 (1887), p. 295.

‡ "Naturgeschichte des Herings," *Abhandl. d. Deutsch. Seefischerei-Vereins*, Bd. II, Hft. 1, 1898.

I. Ratio of head-length to body-length. $P = 0{\cdot}13$, or in only 13 cases in 100 would we expect to find as great a divergence between two samples of the one population.

II. Ratio of position of centre of dorsal fin to body-length. $P = <{\cdot}000095$, or in less than 95 cases in one million would we have as bad a fit.

III. Ratio of position of centre of anal fin to body-length. $P = {\cdot}0003$, or 3 cases in 10,000.

IV. Ratio of position of pectoral fin to body-length. $P = <{\cdot}12$, or less than 12 cases in 100.

V. Ratio of length of dorsal fin to body-length. $P = {\cdot}024$, or 24 cases in 1,000.

VI. Ratio of length of anal fin to body-length. $P = {\cdot}44$, or in 44 cases in every 100 we should expect as bad a result. This is a fair degree of probability.

VII. Ratio of length of caudal fin to body-length. $P = {\cdot}096$, or less than 1 in 10.

Thus in only one of these characters have we any grounds for saying that there is any probability that the two groups of fish belong to the one population, while in most there is a very high degree of improbability.

Thus we are justified, I think, in coming to the conclusion that, contrary to his own opinion, Matthews' results give evidence of a racial distinction between the spring and winter herring of the Scottish coast.

Heincke's figures are, unfortunately, presented in such a form that it is difficult to get series for comparison. The most valuable characters for comparison are the number of keel-scales between ventral fin and anus (K_2), and the number of vertebrae. Unfortunately, out of several tables dealing with fish from one locality we may find only two or three in which these are given, and it is difficult to find a fairly large series of autumn and spring fish from one district in which we can compare the characters.

But we may note the following :—

I. Eastern and Southern North Sea. (Extracted from Heincke's tables 96 to 115).

K_2 (keel-scales)—210 autumn and 254 spring fish.

$P = < \cdot 000001$.

Vertebrae—173 autumn and 250 spring fish.

$P = < \cdot 0000001$.

Here we should have no hesitation in saying that we are dealing with two distinct races.

In this case these are the only two measurements which we can compare. As the autumn group contains a much larger proportion of fish under 100 mm. in length, the indices representing the relative positions of fins and length of head cannot be used, as these change greatly with age in fish up to about 100 mm.

Unfortunately, in Heincke's other groups, the numbers are too small to base any reliable conclusions upon.

Thus in the case of his "Frühjahrs- und Herbstheringe der westlichen Ostsee," K_2 is given in 383 spring herring, but only in 82 autumn herring. This gives $P < \cdot 000001$. In the same group, the head-length is given for 114 spring and 79 autumn fish, and gives the same value for P.

In the case of herring from the Belt and Sound, the numbers of fish are :—K_2, 90 and 77 ; vertebrae, 69 and 59 ; head-length, 91 and 63. The respective values for P are : 0·5, 0·5, and 0·48. Here we have no grounds for distinguishing between the two series. Thus, in the different sub-groups, Heincke's figures give in one case, with fair numbers of fish, strong support to his distinction between autumn and spring fish. In two other cases, where the numbers are smaller, one supports his contention, the other contradicts it.

We cannot lump together some of Heincke's districts to increase the number of fish. If there is anything in his theory of local races we must deal with each district separately.

Thus a comparison of K_2 in the 383 spring herring from the Baltic with 254 from the North Sea gives $P < \cdot 000001$, pointing to the existence of local races independently of the distinction between the autumn and winter herrings.

As regards my own figures, I have already pointed out several reasons why much reliance cannot be placed upon them. But I have tried to find if any were sufficiently accurate to be employed, with the following results :—

In the Port Erin fish we have two samples of 100, numbers (3) and (4) of 1914 (June and July), which give the following results :—

K_2 : $P = 0{\cdot}36$.
D : $P = 0{\cdot}44$.
V : $P = 0{\cdot}4$.
A : $P = 0{\cdot}78$.

Here we find a close resemblance, justifying us in considering these as samples of one population.

Among the Welsh fish we have two samples of 50 each, numbers (8) and (10) of 1914 (December). These are small numbers, but the results are as follows :—

K_2 : $P =$ practically 1.
D : $P = 0{\cdot}5$.
V : $P = 0{\cdot}4$.
A : $P = 0{\cdot}48$.

These, again, we may regard as one population.

Comparing the Port Erin fish with the Welsh, we find :—

K_2 : $P = \cdot 0245$.
D : $P = < \cdot 000001$.
V : $P = \cdot 012$.
A : $P = \cdot 144$.

Thus we can regard it as very improbable that the two areas have the same race of fish. Whether this is a case of

two local races, or of the distinction between summer and winter fish, is a matter for further research.

We may say, then, that this method gives us good ground for supporting Heincke's conclusions and opposing those of Matthews. But more research is needed on large samples from as many areas as possible. These samples must be fresh and in good condition; no method of preservation is satisfactory. Probably the characters on which most reliance can be placed are the number of keel-scales and number of vertebrae, but probably the main reason for this is that these characters can be determined more accurately than the others. In large samples of good fish it will probably be found that the other characters will give quite reliable results.

I have tried to find out whether sex is of sufficient importance to make it necessary to treat the sexes separately. Unfortunately, it is difficult to get large series from the figures available, but the following results may be noted.

Schley Herring:

K_2; 125 ♂, 162 ♀: $\chi^2 = 6{\cdot}3423$: $n = 6$: $P=0{\cdot}28$.

Vertebrae; 92 ♂, 125 ♀: $\chi^2=6{\cdot}775$: $n=5$: $P=0{\cdot}15$.

Herring from Kiel, &c.:

K_2; 92 ♂, 122 ♀ : $\chi^2=6{\cdot}237$: $n=6$: $P=0{\cdot}285$.

Vertebrae; 43 ♂, 52 ♀: $\chi^2=1{\cdot}012$: $n=4$: $P=0{\cdot}8$.

Port Erin, 1914:

K_2; 102 ♂, 96 ♀: $\chi^2=4{\cdot}679$: $n=5$: $P=0{\cdot}325$.

I have also examined the figures given by Duncker* for the sexes in plaice, which give the following results.

Number of rays in dorsal fin:

602 ♂, 518 ♀ : $\chi^2=15{\cdot}81$: $n=17$: $P=0{\cdot}46$.

Number of rays in anal fin:

602 ♂, 518 ♀ : $\chi^2=13$: $n=11$: $P=0{\cdot}223$.

* *Wiss. Meeresunters.*, N. F. IV, 1900.

Number of rays in left pectoral fin :
562 ♂, 498 ♀ : $\chi^2=4{\cdot}5$: $n=6$: $P=0{\cdot}48$.

Number of rays in right pectoral fin :
562 ♂, 497 ♀ : $\chi^2=10{\cdot}083$: $n=6$: $P=0{\cdot}073$.

These figures of Duncker's do not seem to point to any necessity of separating the sexes in this case. In the case of the herring, the numbers are too few to base any reliable conclusions upon, but I think that for the present it may be regarded as legitimate to group the two sexes together for the purposes of the above comparison.

AN INTENSIVE STUDY OF THE MARINE PLANKTON AROUND THE SOUTH END OF THE ISLE OF MAN.—PART IX.

By W. A. Herdman, F.R.S., Andrew Scott, A.L.S., and H. Mabel Lewis, B.A.

[ABSTRACT ONLY.]

In this ninth year of the intensive study of the plankton in the central area of the Irish Sea, although our operations have been greatly restricted by war conditions, we have managed to get 320 samples for examination, spread fairly equally over the twelve months, in numbers varying from 21 to 27 a month. By getting a special permit from the authorities, we have been enabled to take these gatherings in the usual way across the mouth of, and just outside, Port Erin Bay. These bring our total number of samples for the nine years up to 4,620, a very substantial number. We still hope to complete our ten years of work, and then to publish a final report upon the observations of the decade.

We have prepared, in manuscript, a complete report on the year's observations on the usual lines, with tables of statistics, and curves, in the hope that we may be enabled to publish these data with the final report next year. In the meantime we content ourselves, for the reasons which are stated in the Introduction (p. 99), with the following brief account of the results obtained in 1915.

The spring maximum this year was again in May, as it was in 1911, 1913 and 1914, the average haul of the total catch for that month being 63·5 c.c., the highest monthly average in any year we have yet recorded. The actual largest haul was 116·5 c.c., on May 10th. But, although the highest monthly average of the total catch was in May, the monthly averages of the three most important groups in the plankton—

Diatoms, Dinoflagellates and Copepoda—were higher in June. Apparently the greater bulk of the catches on some occasions in May was due to the unicellular Alga Halosphaera.

The autumnal maximum was very slightly marked this year. In 1913, we recorded an unusually low autumnal increase, with an average of 8·4 c.c. in September, and a maximum of 15·2 c.c. This year the numbers are only slightly higher, the average for October being 8·9 c.c., and the maximum catch being 19 c.c. (on September 30th).

There seem to have been no vast swarms of Diatoms this year in our district, such as we have had to record in some previous years. The maximum haul was about 19 millions on June 15th, whereas we recorded hauls of from 150 to about 200 millions in the three previous years.

Our detailed analysis of the more important genera of Diatoms does not show anything of outstanding importance, but, for the most part, simply confirms what we have stated in previous reports. It may be remarked, however, that *Coscinodiscus* was unusually abundant in the spring of 1915. The maximum for this genus was in April, and a record haul of nearly 5 millions was obtained on April 13th.

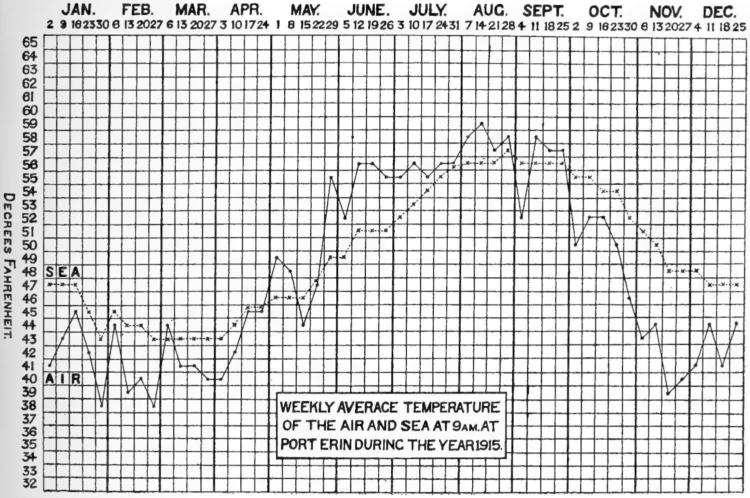
The Dinoflagellata (*Ceratium* and *Peridinium*) were more abundant in 1915 than usual. The maximum for both genera was in June, a month later than in 1914. The largest hauls were 264,000 of *Ceratium tripos* on June 21st, and 110,000 of *Peridinium* spp. on June 3rd.

The maximum of adult Copepoda was this year in August (117,340 on August 2nd), but the highest monthly average was in October; while that of the Copepod nauplii was in June. Our analysis of the eight commonest species of Copepoda shows nothing exceptionally noteworthy in their occurrence during 1915. In some cases the autumnal numbers were relatively higher than usual.

The remaining groups of animals (such as Medusae,

Cladocera, Sagitta, Oikopleura, &c.) and the various kinds of larvae (Echinoderm, Molluscan, &c.) which make up the rest of the plankton gatherings have been identified and computed as usual, and we have detailed records of the statistics of their distribution throughout the year. We find, however. that they present no unusual features, but simply confirm more or less exactly, statements which we have given in previous reports. This confirmation of our previous results, which becomes more and more marked as we continue the work, gives us hope that when our ten years survey of the plankton is completed, we may be able to formulate reliable average results which will hold good for, at least, normal years and seasons.

We give here the usual temperature chart of Port Erin Bay, drawn up from Mr. Chadwick's daily records.



SHELL-FISH AND SEWAGE INVESTIGATIONS.

By James Johnstone, D.Sc.

It has been necessary to spend considerable time during the last year in investigating the shell-fish beds in various parts of the District. These inspections and analyses were made with reference to the mussel beds in the Estuaries at Aberdovey, Barmouth, Portmadoc, the Lune, and the Estuary of the Ribble. Visits were made to these places, and various series of analyses of shell-fish and water were made in reference to each area. Sites for the establishment of cleansing tanks, &c. were decided upon in the cases of the Aberdovey and Barmouth areas, and suggestions for the construction of the tanks were made for the guidance of the Surveyor who designed the tanks. Plans were made by the latter and approved (after some slight emendations). The Committee have now seen these plans.

It was decided that the conditions at Portmadoc were, in the meantime, very unfavourable. It was stated that the whole sewage system of this town was likely to be altered, and in these circumstances it was felt that it would be premature to proceed with any scheme for purifying the mussels.

Various defects in the existing sewage arrangements at Aberdovey and Barmouth have been pointed out, and the attention of the local authorities concerned has been directed to these. It is hoped that they may be remedied, as the complete success of the working of the mussel cleansing tanks may be prejudiced by their continued existence.

Much time was spent in relation to the investigation of suitable places for mussel relaying in the Estuary of the Lune. A short account of these investigations is given in the following pages.

Some other investigations having reference to much needed information with respect to methods of analysis of shell-fish, and permissible standards of sewage contamination are in progress. It is hoped that a complete account of these may be given some time in the future.

(1) The Cardigan Bay Mussel Fisheries.

A report on the results of inspections made in reference to these shell-fisheries, and on the results of analyses, was presented to the Scientific Sub-Committee at the meeting in November, 1915. This is now reprinted as an Appendix to the present Annual Report.

(2) The Mussel Fisheries in the Estuary of the Lune.

Complaints by the Health Authorities.

Here, also, the local conditions required considerable attention. During October and November repeated complaints were made to the Committee and the Lancaster Health Local Authority. The precise genesis of these complaints is not very clear. In some instances, they appear to have arisen in consequence of the results of analyses of mussels taken from markets and shops, and made for the Fishmongers' Company. These analytical results were then communicated to the local authorities. In other instances, they appear to have arisen as the result of investigations made by the local authorities into cases of enteric fever in their districts.

Evidence on which complaints were based.

In neither case was the evidence implicating the mussels satisfactory. It is unsatisfactory merely to take a sample of mussels from a market stall, or shop, and then to extend the results of the analysis to the natural bed from which the shell-fish were said to have come. The mussels may have been contaminated after removal from the fishery, and the statement of their place of origin may have been erroneous.

Neither, unless one knows exactly what has been done, can we unhesitatingly accept the statement that a definite batch of mussels caused enteric fever in the person eating them; nor can the original diagnosis of enteric fever always be accepted as true; nor can it be quite certain, in most cases, that there were not other equally probable causes of the disease should the nature of the latter be verified.

Also, the mussels analysed and reported upon were often simply described as shell-fish coming from the locality of the railway station from which they were carried to the market. Since the same railway station often serves mussels taken from polluted and unpolluted beds, serious mistakes may thus be made. Some instances of such mistakes have recently come to our notice.

Relaying Operations in the Lune Estuary.

In consequence of the complaints referred to above, a conference was held at Glasson Dock. Dr. Jenkins and I met the local fishermen and their representatives, and a provisional scheme of relaying was agreed upon. An Inspector of the Fishmongers' Company had previously visited the district and, it was stated, had advised the fishermen that their mussels might be relaid anywhere on the foreshore, above the level of two hours ebb tide, on neap tides.

Three places were therefore suggested by the men as suitable for relaying, (1) on Crook Skear; (2) at Fishnet Point, near Glasson Dock; (3) in the bight near the entrance of the Conder Brook, near Glasson Dock Railway Station; (4) also, some men working on the Skears near Abbey Light wish to relay their mussels at a place there.

Experiments were made, at the request of the fishermen, at each of these places. I was convinced that sites (2) and (3) were unsuitable; nevertheless, the tests were made. A quantity of mussels were relaid at each of these four places, and samples of these uncleaned mussels were sent to me at the time when

they were laid down. No more than about 18 hours elapsed in any case between the collection of the sample and its analysis.

Samples were also sent from each place after 48 hours relaying, and in the case of the Crook Skear site an additional sample was sent after 11 days.

The places (2) and (3) were unsatisfactory. This is unfortunate, since they were very near to the railway station, and, on that account were favoured by the men. The relaid mussels, after 48 hours, were more highly contaminated than the original un-relaid mussels. These results are anomalous, and are partly due to the exceptional floods in the river, and partly to other causes as yet suspected only.

The place at Crook Skear was satisfactory. There is a little shallow pool on the shore here, which fills at about half-tide. Samples of water were taken from this pool and from the adjacent channel near the level of low water. The results of analysis were :—

The water in the pool ...	0	intestinal	organisms	per c.c.
The water in the channel	40	,,	,,	,,

An experimental relaying gave the following results :—

Original uncleaned sample	5,200	intestinal	organisms	per mussel.
Relaid for 48 hours ...	416	,,	,,	,,
Relaid for 11 days ...	120	,,	,,	,,

There is, of course, little real difference between the mussels relaid for 2 days and those relaid for 11 days. I regarded this experiment as satisfactory.

Several men fish the Skears near the Abbey Light, and relay their mussels on the foreshore at Plover Point, near Cockersand Abbey. Samples of these mussels were sent to me and examined: they contained about 500 intestinal organisms per mussel. Samples were also sent to Professor Delepine, of Manchester University, who found *B. coli* in 1/1,000th, but not in 1/10,000th part of a mussel. These

results are practically similar to mine. This latter place I also regard as satisfactory.

The Commercial Relaying.

During November, and up to the present time, the Lune mussel fishermen have been relaying their mussels at these places—Overton, Sunderland Point, Crook Skear, and Plover Point. Several samples have been sent to me and these have proved to be satisfactory. At each place one man is entrusted with lead seals and an embossing plyers. Stamped seals are affixed to the bags containing mussels which have been relaid in places recommended by the Fisheries Committee.

The Enquiry at Lancaster.

This was held on January 25th. The main question at issue was the choice of a site. I strongly recommended the adoption of one site, that near Overton, for all Lune Estuary mussels, first, because this place is better than the others in its distance from the main channel, and mainly because at one place there could be efficient supervision of the methods of relaying and the system of certification. Practical difficulties, on the part of the men, were pointed out, and the Enquiry adjourned without making an Order under the Shell-fish Regulations. There is to be a Conference later on.

(3) The Ribble Estuary Mussel Fisheries.

This was also an Enquiry under the Shell-fish Regulations, and it was of particular interest in some ways. The genesis of the Enquiry was a complaint from the local authority of Batley, Yorkshire, that "Lytham mussels" were conveying enteric fever, or at least were suspected of doing so. Samples of mussels from the Training Wall in the Ribble Channel, opposite Ansdell, were examined by the Bacteriologist of the Fish-mongers' Company and reported as being unclean.

Evidence justifying condemnation of shell-fish.

It was elicited by Dr. Jenkins in examination of the report made by the Medical Officer of Health for Preston that the latter had no epidemiological evidence causing him to suspect these mussels (those from the Training Wall, and from Church Scar, which is near Ansdell). Large quantities of the same mussels, it was stated, were consumed in and near Lytham without ill-effects by 2,500 soldiers who had been there for some time, for instance. (It was not stated, however, that these men had been inoculated against enteric fever !) However, there was really no epidemiological evidence. The Local Government Board, in their letter covering the issue of the Regulations, deprecated sole reliance on bacteriological analyses in the procedure of the Enquiries. The local authorities were recommended to trust rather to epidemiological and topographical evidence.

Yet the evidence considered at these Enquiries, and in the proceedings that led up to them, was almost entirely that of bacteriological analysis. In both, the proceedings were adjourned, and it was apparent that the evidence brought forward did not prove convincing to the Committees. Those taking part in future Enquiries of this kind should be strongly reminded that the Regulations require that the Medical Officer of Health should have grounds for belief that shell-fish are actually conveying disease, or are *likely* to do so. "Likely," it should be noted, is to be regarded as synonymous with "probable." The proof of this probability, that suspected mussels do convey disease in specified instances, should be required by those opposing or delaying the making of these Orders.

Bacteriological Methods and Standards.

This Preston Enquiry was also notable in that, for the first time, the questions of methods of analysis and standards of impurity arose legally in regard to shell-fish.

Analytical results were submitted from the bacteriologist of the Fishmongers' Company, and from Professor Delepine. It came out in the proceedings that the former analyses were vitiated by the obsolete methods employed. Further, they were so obtained that they could not be compared with the results obtained in other laboratories, being too indefinite. These results could hardly be said to be strictly quantitative ones, since mussels coming from places that might be expected to be very differently polluted did not appear to be significantly different when analysed. Thus a series of analyses, made for the Fishmongers' Company, of mussels before and after relaying at Overton in the Lune showed no appreciable difference, a result that could not reasonably be expected. (These results, which I have seen, were marked "For private information only," but since they are being used in relation to public enquiries, and may affect a public industry, this direction may justly be ignored).

(4) Bacteriological Standards.

No standard was given by the Fishmongers' Company, at least, none was quoted in these proceedings. A standard suggested by Professor Delepine was, however, announced. It was suggested that mussels showing less than 1,000 *B. coli* per individual might be passed. I agree with this standard, since it has practically been that adopted in the work done for the Fisheries Committee. It is to be hoped that further Enquiries will lead to its general use—with necessary and obvious limitations.

Limitations of a Bacteriological Standard.

Let 1,000 *B. coli* be the standard, that is, mussels giving higher results than this are to be condemned, or suspected of undesirable contamination likely to be prejudicial to the public health. Suppose that mussels contain on the average, 1,010 *B. coli* each, are they to be condemned? If so, what

is the real significant difference between 1,000 and 1,010?

This is the legal quibble of "the heap," and it is to be avoided in two ways. (1) By regarding bacteriological analyses as results to be supplemented *always* by epidemiological results. This is the line taken by the Local Government Board. Whether or not mussels with rather more or less than 1,000 *B. coli* per individual are to be condemned, depends on collateral evidence.

(2) By using the results statistically. *Quantitative biological results are useless for comparisons unless they are treated and interpreted statistically.* The crude data of observation are less reliable than statistically corrected data. When we find from experiment that five mussels contain, on the average, 1,000 *B. coli* each, we must assume that the figure 1,000 is subject to an error, the size of which depends on the methods, &c. It may be that any result from 900 to 1,100 is to be regarded as equally probable, given a certain standard of probability adopted at the outset.

If, then, there is collateral evidence against the shell-fish, we may regard (say) a result of 900 as the same thing as 1,100, and so condemn the mussels. If, on the contrary, there is no prejudicial collateral evidence, we may regard a result of 1,100 as not enough to condemn the mussels.

A Legal Definition of B. coli.

It is desirable, and will become more so as further Enquiries are held, that there should be a legal definition of *B. coli*. Bacteriologists, at least research bacteriologists, are already probably in agreement as to the characters diagnostic of this micro-organism, but a uniform treatment of material submitted for analysis is very desirable in public health routine work. The methods of analysis may, of course, vary according to the laboratory, but they should be so directed that they will give the mean numbers of *B. coli* contained in each of (say) 5 or 10 mussels, cockles or oysters; and they

should find *B. coli* to be an organism (say) growing rapidly in bile-salt media, fermenting glucose, lactose and dulcite, and producing indole, but failing to ferment cane-sugar, inulin, and adonite, and failing to give the Vosges and Proskauer reaction. This is the standard adopted in the analyses made for the Fisheries Committee. If a less stringent diagnosis is adopted, say that of an organism growing rapidly in bile-salt media, fermenting glucose and lactose, and giving the indole reaction and a neutral-red fluorescence, then the results should indicate the contamination as due to "intestinal," or "faecal" or some other category of organisms.

The Necessity for Bacteriological Analyses.

Even when due stress is laid on epidemiological results, bacteriological analyses are necessary: topographical evidence can hardly be considered without this adjunct. The investigation of suitable and practicable places for relaying, and the criteria of the results of relaying, must obviously be obtained by analyses.

APPENDIX I.

(From Quarterly Report of November, 1915)

Dr. Johnstone's Report on the Cardigan Bay Mussel Order.

As it seemed likely that this Order would come into force during last quarter, a good deal of time was spent in making preliminary investigations in order that suitable methods of treating the local mussels might be devised. In addition to visits of inspection and analyses previously made and reported upon, I spent about a week at both Aberdovey and Barmouth during June, and had the ready and careful assistance of Captain E. Lewis, the local Fishery Officer, on these occasions. Subsequent collection of samples was made by Captain Lewis, and I am very much indebted for this help, which made further visits to Cardigan Bay unnecessary.

All three estuaries, at Aberdovey, Barmouth, and Portmadoc, presented great difficulties. The mussel industry is a very small one, involving perhaps some two dozen fishermen regularly during the season. The expense of providing means of purifying the shellfish had to be proportionate to the value of the industry. At all the places, however, a considerable degree of development may be regarded as probable. There is much scope for transplantation and fattening of small seed mussels otherwise valueless, and this transplantation depends for its success upon the provision of means for purification. It is desirable that the small seed mussels should be transplanted into those parts of each estuary where growth will proceed most rapidly; that is, into the places where there is most sewage. The mussels must then be so treated as to remove the contamination—that is, the sewage bacteria—taken in during the last day or two of the growth period.

Ambitious and expensive works, such as those now

being completed at Conway by the Corporation and the Board of Agriculture and Fisheries, could not be projected. On the whole, the best means of dealing with the problem might have been to centralise it. It would have been possible to erect tanks on some part of the coast between Harlech and Aberystwyth capable of dealing with all the mussels taken in Cardigan Bay. The shellfish could have been bought from the fishermen, treated in the tanks, certified and put on the market. After deduction of working and depreciation expenses, a bonus on each season's profits could have been declared and paid to all fishermen taking out licences under the Order in proportion to the total quantity of mussels gathered by them and sent to the "sanatorium." There are, of course, different qualities of mussels, obtaining different prices, but this difficulty could easily be provided for. This method of dealing with the Cardigan Bay mussel fisheries might have been, taking a broad view of the question, the best means, I think, of dealing with it. It may be impracticable at the present time, but I suggest it here so that it may yet be considered after the preliminary steps now being taken are tested. By adopting such a plan, working expenses might be centralised and diminished, and the best natural situation for the tanks could be fixed upon apart from other considerations. The open coast of Cardigan Bay is bathed by water of exceptional freedom from sewage pollution. There would be no necessity to sterilise the water flowing into the tanks by treatment with chemicals. It must be noted that a shellfish is cleansed from sewage bacteria by a process of washing-out. Sterile sea-water is taken into the shell cavity and alimentary canal and removes the bacteria as it flows out again, and so long as this circulating water is sterile no further contamination can take place.

If the tanks for purifying the mussels are erected, one in each estuary, additional difficulties are set up. It is necessary to place these tanks on such parts of the foreshore as are convenient from the point of view of construction, and where water of sufficient purity can be obtained. Further, pumping cannot be employed in such small installations because of the initial and working expense of the plant of engines, etc., so that the tanks must be tidal ones. Finally, the tanks must be placed where they are convenient for the fishermen, that is, near to the musselling grounds, and to the railway stations. Places which are, from the point of view of construction and purity of water, the most suitable ones may involve much difficulty by way of getting the mussels there and removing them after treatment, and it is to be feared that insistence on such places would simply kill the industry. Add to these difficulties that of supervision—the treatment of the mussels in the tanks for the necessary time, and the certification of the bags before despatch to the markets—and it will be seen that the problem of devising means of purification for the Cardigan Bay mussels is by no means an easy one.

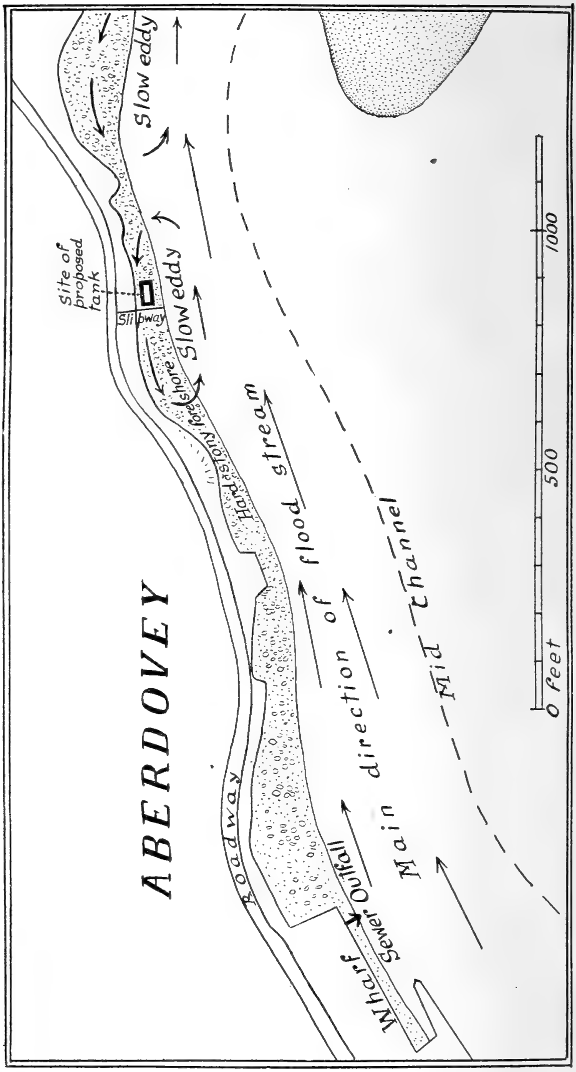
I am putting the difficulties as clearly as possible, but as things are the adoption of the present scheme is imperative in the interest of the industry, and much is to be gained by making the attempt. We hope, also, to overcome the difficulties suggested above when the scheme is made to work.

We may now consider each estuary separately.

(1) *Aberdovey.*

The sketch chart on the next page shows the part of the estuary adjacent to the proposed tank. The dotted line, in the water, represents approximately the middle line of the channel. It is proposed to place the tank on the foreshore to the east of the Lifeboat Slip. The tank

is to be built of concrete walls, with a concrete foundation and bottom. The walls rise up to the level of high-water



of the lowest neap tides, and the tank is to have a depth of about three feet of water when the tide has exposed

it. It will be emptied by a series of sea-cocks just before high water, and filled again by the tide flowing over the tops of the walls. The water emptying from the tank, and containing refuse matter washed out from the mussels, will thus be carried away by the flowing tide, and clean flood-tide water will take its place.

The sewer outfall is marked on the sketch chart, and a series of arrows showing the direction of the flood-stream. The current sets directly from the sewer outfall up the channel in the direction of the tank, but when the stream is running very strongly in the channel it is practically still water at the place of the tank, except for a slow eddy circulating in the opposite direction to that of the tidal stream. It may be thought that this arrangement involves risk of contamination of the tank from the sewer, but I do not think that this will be so. First of all, the main drift of the flood-stream is past the tank, and the eddying water will be greatly diluted. This dilution is very great, for Mr. Durlacher's figures (published in the Annual Report for 1913) show at high water the density of the water in the estuary is everywhere practically the same, and about that of the sea outside the bar (about 1·026). At low water the density is also nearly uniform, but is now about 1·007 to 1·010. There is therefore a very great rise in density during the later part of the flood-stream, indicating an enormous dilution of the estuarine water by water from the open sea. Only traces of sewage can thus reach the tank in any circumstances.

An extensive series of bacteriological analyses of the water over the site of the tank was made in June, both from samples which I collected myself, and some sent me by Captain Lewis. Thus:—27th June, means of two series of analyses.

	Per Cubic Centimetre.
Collected at $\frac{1}{2}$ ebb-tide	109 sewage bacteria.
,, ,, $\frac{1}{2}$ hour after $\frac{1}{2}$ ebb-tide ...	17 ,, ,,
,, ,, 1 ,, ,, ,, ...	15 ,, ,,
,, ,, 1 ,, before $\frac{1}{2}$ flood-tide	12 ,, ,,
,, ,, $\frac{1}{2}$,, ,, ,,	12 ,, ,,
,, ,, $\frac{1}{2}$ flood-tide	3 ,, ,,

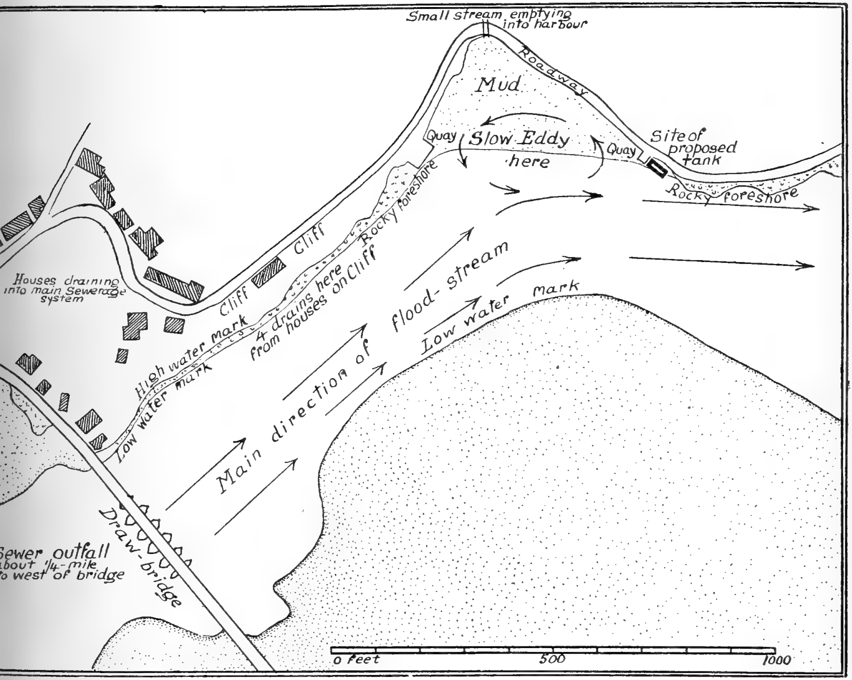
And on 2nd July, means of two series of analyses.

	Per Cubic Centimetre.
Collected at 1 hour before high water ...	0 sewage bacteria.
,, ,, $\frac{1}{2}$,, ,, ,, ...	2 ,, ,,
,, ,, high water	4 ,, ,,
,, ,, $\frac{1}{2}$ hour after high water ...	20 ,, ,,
,, ,, 1 ,, ,, ,, ...	Numerous sewage bacteria.

To understand rightly these figures we must remember that the numbers of sewage bacteria per cubic centimetre of crude domestic sewage are to be reckoned by the hundred thousand. Still there are apparently anomalous results in that the water just after high water may contain more sewage bacteria than one can regard as desirable. This result is, however, easily explained away. It is the practice at Aberdovey to liberate the sewage from the main outfall during the flood tide so as to avoid fouling the sands where bathing goes on. This occurs during June and July, in which months my samples were collected. When the bathing season is over the sewage is, I believe, discharged at all states of the tide. Probably, then, the contamination of the shore on the site of the tank is much more likely during the holiday season than it would be during the mussel season in the winter months. It is small, at the worst, and it may effectually be prevented by arranging to liberate the sewage, during the mussel season, only on the ebb-tide. This ought to be as easy to do in the interest of the mussel industry in the winter, as the opposite procedure is in the interest of holiday-makers in the summer. If it is conscientiously carried out, the tank will remain unpolluted.

(2) *Barmouth.*

The plans for the erection of a tank at Barmouth are very similar to those for Aberdovey. The sketch chart shows the part of the Estuary where it is proposed to carry out the works. I visited this place twice during last June, and further samples of mussels were collected for me by Captain Lewis. It was suggested by Captain



Lewis that a tank could be placed on the shore just East from Aberamffra, between two prominent rocks jutting out from the shore. On further consideration, however, we decided to recommend that the tank be built close to the Eastern Quay at the place marked on the chart.

The direction of flow of water in the Estuary, and

the probable drift of sewage, were worked out by Mr. Durlacher, and his results were given in last year's Annual Report. By far the greater part of the sewage is discharged from the main sewer well outside the mouth of the Estuary, and this cannot affect the water at Aberamffra. But there is another broken sewer pipe discharging into the Estuary about a quarter of a mile below the Bridge, there are some privies on the quay-side, and there are drains from four houses on Aberamffra Cliff which discharge directly on the foreshore. These are the sources of contamination. A very unfortunate condition, affecting Aberdovey, Barmouth and Portmadoc, is the configuration of the Estuaries. Because of the sandbanks and the very shallow water on the bars, these are, to some extent, "bottle-necks." In each case the Estuary is wide above, and narrow at its mouth, and as a result there is not a complete change of water at neap tides. At Barmouth and Portmadoc the water in the upper parts of the rivers is probably changed completely during the springs, but at neaps only a part becomes carried out to sea. Some water therefore oscillates up and down between the bar and the upper reaches for several days, becoming charged with sewage all the while. This is less the case at Aberdovey than in the other two Estuaries, but it is still a matter to be considered.

At Barmouth the flood stream takes the general direction indicated by the arrows drawn on the sketch chart. Water previously containing sewage flows close to Aberamffra, but does not enter the harbour directly. There is a slow eddy there which is roughly indicated on the chart.

It might seem, therefore, that the proposed situation of the tank is such that it cannot avoid contamination,

and Mr. Durlacher was of opinion that Aberamffra was an unsuitable place for a tank. But on consideration of all the facts I do not think the risk of pollution will be significant *provided that certain alterations in the existing sewerage can be carried out.* Mr. Durlacher suggested that Penrhyn Point and its neighbourhood was the best place in the Estuary, but while this may be so, it will probably be found that this place is inconvenient for the fishermen, who will then refuse to use it. The risk taken at Aberamffra is that from the sewer in the harbour and from the drains at the houses on Aberamffra Cliff. Now the sewer in the harbour ought to be repaired, and it does not seem a difficult task to connect together the separate drains from Aberamffra Cliff and arrange that they discharge by a single outfall on ebb-tide only. It seems to me to be an easy task for an engineer to arrange a flap at the mouth of the outfall sewer, worked by a buoy which will open the flap when the tide is ebbing and close it when the flood stream begins. These two changes in the existing sewerage would probably prevent any serious contamination of Aberamffra harbour.

Further Mr. Durlacher's results show that there is a great rise in the density of the water at Aberamffra between low water and high water—a rise very similar to that at Aberdovey. This indicates a very considerable dilution of estuarine water by open sea water, and encourages us to think that water taken at about the time of full flood will be practically uncontaminated.

No water samples were taken at Aberamffra, for it was found that there were plenty of small mussels on the rocks at the place where the tank is to be constructed. Two series of samples of these mussels were taken, and estimates of the contained sewage bacteria were made.

22 June, 1915. Neap tides. Half-flood tide.
Present in 1/50 part of a mussel (5 estimations)
1, 1, 0, 2, 0 sewage bacteria.

22 June, 1915. Neap tides. Low water.
Present in 1/50th mussel (5 estimations)
1, 1, 2, 0, 0 sewage bacteria.

30 June, 1915. Spring tides. Half-flood tide.
Present in 1/50th mussel (5 estimations)
2, 1, 1, 1, 1 sewage bacteria.

30 June, 1915. Spring tides. Low water.
Present in 1/50th mussel (5 estimations)
12, 7, 5, 12, 8 sewage bacteria.

In none of these cases can I regard the amount of pollution indicated by the analyses as significant, and one must remember that the conditions will be materially improved by the alterations in the sewerage which I have suggested above.

(3) *Portmadoc.*

The situation with regard to the mussel fisheries at Portmadoc is rather different from that at Aberdovey or at Barmouth. The industry there has practically been stopped on account of the embargo laid on the mussels by several market authorities. It is a bigger industry than that at the other two estuaries, though it is very small compared with the great mussel fisheries of Conway and Morecambe when these were at their best. Some remedial measures are very desirable in the case of Portmadoc, especially this season when mussels appear to be unusually abundant in the estuary. The difficulty in dealing with this place is not only that of expense, but as Dr. Jenkins pointed out in his Report of June last, a harbour improvement scheme is being promoted. Further, a sewerage scheme has been suggested, and is apparently in abeyance in the meantime. In the circumstances of possible new sewers and changed river

channels, it seems unwise to proceed with the erection of tanks which might become unsuitably placed.

I visited Portmadoc on 13th October, and saw the place which was suggested locally as suitable for the erection of a mussel cleansing tank. This was on the South slope of the Ffestiniog Railway embankment, in the angle between this and the "New Wharf" (see my chart in the Annual Report for 1913). It did not seem to me to be a suitable place, and until a report has been obtained from a Surveyor as to the practicability of erecting a tank there at a reasonable cost the project can hardly be discussed. Samples of water were taken for analysis from the place suggested, and the results are as follows:—

About	½	hour ebb,	24	sewage bacteria	per cubic centimetre.
,,	1	,, ,,	31	,,	,,
,,	1½	,, ,,	10	,,	,,
,,	3	,, ,,	7	,,	,,
,,	3	,, ,,	15	,,	,,
,,	3	,, ,,	6	,,	,,

At about 3 hours' ebb the sands South from the embankment had dried, and the samples were taken from different parts of a small channel running nearly parallel to the embankment. The contamination indicated by these samples was not excessive, but it is greater than is desirable.

The most satisfactory provisional way of dealing with the Portmadoc mussels would be to take them to the tanks either at Aberdovey or Barmouth for treatment. I understood, however, that the fishermen were reluctant to agree to this proposal.

A New Mussel Bed at Bardsea.

On 4th October, Mr. A. Scott and I visited a mussel bed now forming at what is called Wadhead Scar, near

Conishead Priory, near Ulverston, in Morecambe Bay, The bed was examined and samples were taken for analysis. No indications of sewage on the bed itself could be detected. The analysis gave what I regard as satisfactory results:—In 1/25th part of a mussel there were 13, 15, 20, 31, 10 sewage bacteria (in 5 estimations).

Considering these low counts, and the distance of the mussel bed from any considerable source of pollution, I think that the latter may be regarded as free from serious contamination.

APPENDIX II.

(*From Quarterly Report of November*, 1915.)

Mr. Scott's Report on the Morecambe Bay "Whitebait" Fishery and Mussel Beds.

Visits have been made recently to two of the fishing centres in the northern area of Morecambe Bay to inspect the "whitebait" fishery and the mussel beds at the respective places, and to gather any information and specimens of value.

The "whitebait" fishery at Morecambe, which has developed into a valuable asset to the fishermen there during the winter months, has suffered owing to the war. The fish have also been very scarce during the past summer. Previous to the war, good prices were being obtained in the London markets, but the sale at remunerative prices is now almost impossible. A considerable trade has more recently been done in connection with a demand for preserving purposes "somewhere in England." In the winter months, and until at least the beginning of March, the majority of the marketable "whitebait" caught at Morecambe are nearly adult sprats. The range in length is from $3\frac{1}{4}$ to $4\frac{1}{2}$ inches. When the reproductive organs reach maturity the sprats migrate into deeper water to spawn, and the coastal fishery may then become unproductive. The reproductive organs of sprats caught at Morecambe reach maturity in February, and the adults soon after disappear. It apparently frequently happens that when the sprats leave the inshore waters to spawn, they are replaced by shoals of young herring from $2\frac{1}{2}$ to $4\frac{3}{4}$ inches in length. This invasion of young herring, if extensive and lasting, may prolong the "whitebait" fishery throughout the summer months. Some of the samples of Morecambe "whitebait" examined during the past

summer contained 86% of young herring. The remaining 14% were young sprats $2\frac{1}{4}$ inches long. When the sprats disappeared from the Morecambe area early in the spring of the present year the shoals of young herring failed to appear in any quantity. The prosecution of the fishery was, of course, abandoned for the time being. The only places where samples could be obtained for examination were the "baulks" at the West end. The fish were left stranded by the receding tide and gathered up by hand. The stranded fish were occasionally used to bait the eel traps by the owner of the "baulks." The "baulks" act as a barometer to the "whitebait" fishermen, and they know from the quantity stranded whether it will be worth while applying for permits to use small-meshed nets for their capture. The fishermen complained of the decreased demand in the London market owing to the giving up of "whitebait" dinners, etc. I suggested that an attempt might be made to induce the owners of fried fish shops to use "whitebait" if the usual fish supplies were unavailable. Some of the owners of the shops were interviewed, but they were not very enthusiastic. They say the usual supplies of flat and other fish are well maintained, and they have no difficulty in getting what they want. This was certainly the case when I visited Morecambe. I saw some very fine catches of soles, cod, etc., which had been landed by the local half-decked boats that morning. Some of the more enterprising fishermen might try the experiment for themselves on the visitors in the same way as they have developed the potted-shrimp industry. "Whitebait" caught and used locally is to be preferred to that which has had a long railway journey.

The Ulverston mussel beds were visited twice, the first time with Dr. Jenkins and the second time with Dr. Johnstone. The Priory bed, which has occasionally

produced good mussels in the past, is now almost entirely destroyed by the alteration of the channel. The bed was formed on the edge of the channel leading to the pier belonging to the North Lonsdale Iron Company. This channel was much used by small steam vessels coming to load pig iron, and a good deal of fresh and other water from Ulverston found its way by it to the sea. The channel is now filled up by the shifting sands of the Bay, and the steamer traffic ended. The silting up of the Priory bed is not a great misfortune, as Dr. Johnstone has shown in one of his reports that it was contaminated by sewage. It was not very desirable, therefore, that the mussels should be used as food. The Bardsea bed on the edge of the same channel that formerly flowed past the Priory bed is about a mile further West. It is covered with a good supply of small mussels, but there are very few that are much over 2 inches long. There is little prospect of a fishery during the present season. The bed is not quite beyond the reach of sewage, and the mussels may occasionally be slightly contaminated.

When we visited the Bardsea bed our attention was drawn to a flock of gulls which were feeding on the adjacent sands, and to the excreta evacuated by them. These excreta consisted of well-defined heaps of white, pale pink and dark shells. The white shells proved to be fragments of barnacles, which the birds had obviously broken away from stones, mussel shells, etc. The pink heaps represented the shells of "henpens" (*Tellina balthica*), which live close to the surface of the sandy mud between tide marks. The dark heaps consisted of comminuted mussel shells. The heaps were practically pure, showing that the gulls had applied themselves to one kind of food at a time. The barnacles, "henpens," and most of the mussels had obviously passed right through the alimentary canal, and were very fragmentary. In some

cases, however, it was evident that the mussel shells had been regurgitated, as they were quite whole, the soft parts were undigested, and the valves not even separated. Some of the undamaged shells measured 23 millimetres, or nearly an inch in length. In the Quarterly Report drawn up in January, 1910, I reported on the destruction of young cockles by gulls on the Flookburgh beds. These beds are on the opposite side of the Leven from the Ulverston mussel beds. They extend eastward along the sands in front of the village of Flookburgh, and still further East. Since the beginning of the war, many of the Flookburgh cocklers have gone into the munition works, and the fishery has decreased. The reduced fishery doubtless leaves more cockles undisturbed in the sands than when there is great activity. It is difficult to say whether cockles, when undisturbed, are beyond the reach of the seagulls. The fishermen say they have seen the gulls tread the cockles to the surface with their feet, much in the same way as a man uses the "jumbo." This may be an exaggeration. When the cockle fishery is being prosecuted, the cockles collected are riddled to remove the undersized ones. These are usually left on the surface of the sand, and are practically presented to the gulls. It may well be that in the absence of a cockle fishery the gulls are compelled to obtain other food, and so take what is easily to be had. This would explain their feeding on barnacles, "henpens" and young mussels, as these are all on, or very close to, the surface of the sand. The fisherman will not object to the destruction of every barnacle along the shore, as he looks upon them as an affliction that could be well done without. "Henpens" and young mussels, when abundant, generally attract flounders and plaice. An extensive competition by gulls for this kind of food might interfere with the development of a fluke fishery.

ON THE TUBE OF A RARE POLYCHAETE WORM, *TEREBELLA* (*LANICE*) *SETICORNIS*, McIntosh, DREDGED WEST OF THE ISLE OF MAN.

By ARNOLD T. WATSON, F.L.S.

[Read 12th May, 1916.]

The specimen to which this note refers was collected by me about 20 years ago, when dredging with Professor Herdman and the members of the Liverpool Marine Biology Committee, to the west of the Isle of Man, 20 to 30 fathoms.

The *tube* only was secured, of which a full-sized drawing is now given (see fig. on next page).

This tube, the bore of which is $\frac{3}{16}$ in. (say 4 mm.) and the length over all $3\frac{3}{4}$ in., is formed of fragments of shell and flat stones. These fragments in the lower part are fairly large, but for a short distance, just beneath the two triangular plates, or palms, which support the radiating filaments forming the fans, the fragments are much smaller and the external diameter of the tube is consequently reduced.

The triangular palms, although each consisting of about 25 fragments of shell or stone firmly cemented together, are beautifully symmetrical in outline. They are extensions of opposite edges of the mouth of the tube, which are expanded and so flattened out as almost to touch one another.

To the edges of each palm are attached about 14 radiating filaments. These filaments, practically all of which are unbranched, are composed of sand-grains, echinus spines, and miscellaneous material, attached end to end, in single line, supported by the mucous secretion of the worm.

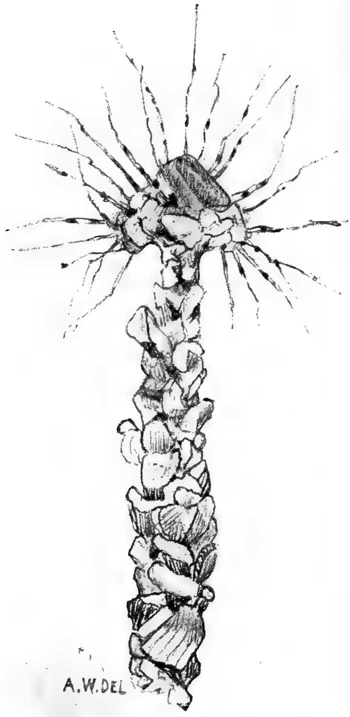
Several of the filaments are incomplete or broken, but 12 are terminated by hair-like processes, consisting of smooth

round hairs, secretal threads, or other material, the exact origin of which it is difficult to decide.

The fan measures $1\frac{1}{2}$ in. across.

So far as I have been able to ascertain, no similar specimen has previously been recorded as British.

Although much larger than the tube obtained from the mouth of the Rio de la Plata, South America, described and figured by McIntosh, in the "Challenger" Report (Zool. vol. xii, p. 448; Plate xlix, Fig. 4), and although there are points of difference as regards the filaments, &c., still the general resemblance between the two is such that I think the Port Erin specimen should be recorded as belonging to the species *Terebella* (*Lanice*) *seticornis*, created by McIntosh for the South American tube.



APPENDIX II

L.M.B.C. MEMOIR: 'MANX ALGAE'

L.M.B.C. MEMOIRS

No. XXX. MANX ALGAE

AN ALGAL SURVEY OF THE SOUTH END OF THE ISLE OF MAN

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CONTENTS.

INTRODUCTION

The present Memoir embodies the results of a systematic survey of the algal flora of the south-east corner of the Isle of Man. The survey has covered a period of some few years and a considerable stretch of coastline has been laid under contribution, from Fleshwick Bay in the west to Castletown on the south-east seaboard. Much of this coastline is too steep to admit of easy access, but wherever possible, the algal flora has been sampled and comparative studies made between point and point.

The area offers considerable variety of algal habitat. Fleshwick Bay (Map II, 1) presents a stony beach flanked by steep cliffs with boulder-fringed base. As a contrast Port Erin Bay (Map II, 4) provides a sandy stretch with emergent rocks, giving origin to a series of rock pools with a rich algal flora. The broken breakwater at the mouth of the Bay also provides the algologist with a profitable hunting ground ; for here, seaward of the tumbled concrete blocks, may be found those genera and species that flourish best in rough water conditions ; while within the shelter of the old boat-landing close by, is a quiet arm of the Bay in which many of the rarer species are to be found, the vertical sides of the concrete blocks offering a specially good collecting ground.

The steep coast lying between Port Erin Bay and the Sound (Map II, 7) is largely inaccessible to exploration from the land except at one or two points such as Bay Fine (Map II, 5) or Aldrick Bay (Map II, 6) where a typical boulder beach with its associated flora may be found. This type of habitat forms an almost continuous strip of varying width round the foot of the cliffs as far as Perwick Bay in the south-east. Here and there the bold thrust of a

headland with precipitous cliffs interrupts the continuity of the boulder beach, and where the land dips down to the Sound the cliffs give way in places to inlets and small bays offering a variety of algal habitats with floras of varied character. Perwick Bay shelters a stone-covered beach, and offers a favourable locality for the study of continuous Fucoid vegetation.

From the point of view of the algologist, however, the most interesting piece of coast in the area is that starting from Perwick Bay, passing through Port St. Mary Bay (Map II, 10), Bay ny Carricky (Map II, 11), Pooyllvaaish (Map II, 12) and following the contours of the coast round Scarlet Point (Map II, 13) as far as the entry of the Silver Burn into the sea at Castletown (Map II, 14).

The tilt of the land is such that the cliffs at Castletown give way gradually to an almost flat coastline. The diminishing steepness results in a gradually extending breadth of shore between tide marks. Much of this piece of coast lies on limestone, and is built up of low terraces almost horizontal in places and with synclinal and anticlinal slopes dipping gently seaward. These limestone terraces offer a type of habitat which stands in sharp contrast to the Fucus-covered boulders of the south-west coast. In places the limestone is worn into a series of hummocks separated by shallow saucer-shaped pools. Here is a locality unfavourable to the development of fucoid vegetation, but one that provides the student with an excellent opportunity of studying the flora of rock pools, especially the type known, on account of the dominance of *Lithophyllum* and *Corallina*, as "coralline" pools.

The rest of the south-east seaboard is made up of stretches of fissured rock, interrupted by patches of sand or of sand overlaid by stones. The general trend of the coast brings it almost parallel to the direction of the prevailing

winds, thus protecting it from the full force of the worst gales. It is, however, fully exposed to such gales as come up from the south-east, gales whose violence is clearly illustrated by the tons of algal vegetation carted from the Castletown shore in the autumn.

In making the survey careful notes have been kept not only of the species found in the area, but also of the time of occurrence, the zone of distribution and the period of reproduction in each case.

In the present Memoir no attempt has been made to give an ecological account of the vegetation. That is reserved for the future. Some attention has, however, been paid to a tentative enquiry into the factors governing algal migrations from level to level on the shore throughout the year. A full and detailed study of the ecology of the area will be the subject of a later paper. Meantime the immediate object of publication is to provide the student-visitor to the area with a guide that will, it is hoped, facilitate his efforts to make acquaintance with the algal flora and to gather some understanding of its variation from one season to another.

THE AREA

In this section no attempt has been made to give an exhaustive list of the species to be found in each area. Information on the exact distribution of each species is given in the systematic list. These notes are intended to give the student who has had little previous experience directions as to the best part of the area to study, and to suggest the commoner genera and species that he might reasonably be expected to recognise.

Port Erin Bay.

Port Erin Bay offers considerable variety of algal habitat. One of the most productive areas lies amongst

the rocks emerging from the sand on the north side of the Bay. Here are developed a series of rock pools that repay careful investigation. It is a difficult matter to give a list of available plants in the pools as they shew a regular procession of genera and species that varies throughout the cycle of the seasons. In the small pools one species may be dominant in March but completely absent at the end of May. The list provided includes species that may be found between February and July.

Seaward of the pool area lies a fringe of Fucoid and Laminarian vegetation which, in late spring and early summer is very productive of interesting genera and species.

The commonest algae obtainable from this area are :—

CHLOROPHYCEAE

Enteromorpha spp.
Ulva spp.
Monostroma spp.
Cladophora spp.
Codium tomentosum (Winter and Spring)
Bryopsis (on the sides of deep pools usually about 6 inches below the surface).
Urospora isogona.
Chaetomorpha spp.

PHAEOPHYCEAE.

Laminaria saccharina
L. digitata
Fucus spiralis
F. vesiculosus
F. serratus
Ascophyllum nodosum
Pelvetia canaliculata
Desmarestia aculeata (low water level)
D. viridis (deep pools in Spring)
Scytosiphon lomentarius
Asperococcus fistulosus
Sphacelaria cirrhosa
Cladostephus spongiosus
C. verticillatus
Castagnea virescens (Summer only)
Dictyosiphon foeniculaceus (Summer only)
Chordaria flagelliformis (Summer only)

RHODOPHYCEAE

Porphyra umbilicalis
Corallina officinalis
Delesseria spp.
Ceramium spp.
Callithamnion spp.
Polysiphonia spp.
Gelidium corneum
Furcellaria fastigiata
Polyides rotundus
Ahnfeltia plicata
Calliblepharis lanceolata
Griffithsia spp.
Phyllophora spp.

The list quoted above will serve for the whole of the north side of the bay, but the character of the flora changes somewhat where the coast lifts into the steep cliffs of the Bradda (Map II, 2) promontory. In Spaldrick Bay (Map II, 3) where fresh water comes down from the land, patches of *Fucus ceranoides* may be found.

Immediately below the Biological Station the inlet sheltered by the old boat-landing should be studied, as its shore provides a sample of zoned vegetation. A very clear Fucoid series can be observed shewing in succession from high water mark downwards :—*Pelvetia canaliculata, Fucus spiralis, Fucus vesiculosus, Ascophyllum nodosum* on the boulders and *Fucus serratus* on the level rocks. Similarly on both sides of the boat-landing and on the broken breakwater itself at low water mark may be seen a Laminaria zone with *L. digitata* above, *Saccorhiza polyschides* in the lower part of the *L. digitata* zone and *L. Cloustoni* below.

In the inlet pool itself at very low spring tides may be found many of the rarer algae, particularly in the crevices between the concrete blocks.

PORT ST. MARY.

The limestone terraces (Plate I) marked on the map as "the Ledges" (Map II, 9) offer an excellent opportunity

ERRATA.

Page 7, lines 7-10. Read as follows:—

ZONE 1. Submerged 5% to 25% of the tidal period.
ZONE 2. Submerged 25% to 50% of the tidal period.
ZONE 3. Submerged 50% to 75% of the tidal period.
ZONE 4. Submerged 75% to 95% of the tidal period.

for the study of shallow rock pools. The far-reaching effects of varying proportions of exposure and submergence are revealed by a careful study of the pool flora and of the inter-pool vegetation of this area.

The area may conveniently be divided into four zones, as follows :—

ZONE 1. Exposed 5% to 25% of the tidal period.
ZONE 2. Exposed 25% to 50% of the tidal period.
ZONE 3. Exposed 50% to 75% of the tidal period.
ZONE 4. Exposed 75% to 95% to the tidal period.

Increasing length of the period of submergence shews corresponding rise in frequency of occurrence for individuals of a species, and a marked increase in the number of species present.

The commonest species obtainable are :—

ZONE 1 (Plate II).

Enteromorpha intestinalis
Prasiola stipitata
Urospora isogona
Ralfsia verrucosa
Scytosiphon lomentarius
Corallina officinalis
Lithothamnion Lenormandi

ZONE 2 (Plate VI).

Lithothamnion Lenormandi and *Corallina officinalis* (co-dominant)
Ulva latissima
Cladophora spp.
Codium mucronatum
Ceramium rubrum (epiphytic on Corallina)
Callithamnion arbuscula (epiphytic on Corallina)
Plumaria elegans (epiphytic on Corallina)
Rhodymenia palmata (occasional)

In Zones 1 and 2 there is no inter-pool vegetation.

ZONE 3 (Plate III).

From the beginning of Zone 3 downwards towards the sea the inter-pool vegetation becomes increasingly evident. The commonest plants in this area are :—

Fucus serratus and *Laurencia hybrida* (between pools)

Pool Vegetation.

Lithothamnion Lenormandi (abundant)
Corallina officinalis (abundant)
Laurencia hybrida (abundant)
L. pinnatifida (abundant)
Cladophora rupestris (abundant)
Himanthalia lorea (abundant)
Cladostephus spongiosus (abundant)
Callithamnion arbuscula (abundant)
Codium mucronatum (frequent)
Ulva latissima (frequent)
Rhodymenia palmata (frequent)
Griffithsia flosculosa (frequent)
Leathesia difformis (frequent)

Zone 4 (Plate IV and V).

The commonest species in this zone are :—

Laminaria digitata (locally dominant)
Himanthalia lorea (locally dominant)
Fucus serratus (locally dominant)
Rhodymenia palmata (locally dominant)
Ceramium rubrum (on *Cladostephus*) (abundant)
C. acanthonotum (abundant)
Gelidium spp. (abundant)
Callithamnion arbuscula (on *Cladostephus* or *Corallina*) (abundant)
Delesseria alata (abundant)
Plumaria elegans (abundant)
Chondrus crispus (abundant)
Laurencia pinnatifida (abundant)
Corallina officinalis (abundant)
Cladophora rupestris (abundant)
Cladostephus spongiosus (abundant)
Rhodochorton Rothii (frequent)
Dasya arbuscula (frequent)
Heterosiphonia plumosa (frequent)
Polysiphonia urceolata (frequent)
P. Brodiaei (frequent)
Laminaria saccharina (frequent)
Ectocarpus spp. (frequent)
Elachista scutulata on *Himanthalia* (frequent)
Sphacelaria cirrhosa (frequent)
Gigartina stellata (frequent)
Delesseria sanguinea (occasional)
Nitophyllum ramosum (occasional)
Halidrys siliquosa (occasional)
Furcellaria fastigiata (occasional)
Scytosiphon lomentarius (occasional)
Lomentaria articulata (occasional)
Chylocladia ovatus (occasional)

The contrast between Zones 3 and 4 lies in the increasing stature and number of individuals of the species present in Zone 4 compared with Zone 3, rather than in any great change in the composition of the flora. In Zone 4 the rock surface in between the pools is well covered by a carpet of vegetation. A striking feature is the dominance of *Himanthalia lorea* with which is an admixture of *Fucus serratus.* The undergrowth is chiefly made up of *Cladophora rupestris, Cladostephus spongiosus, Chondrus crispus, Laurencia pinnatifida, Chylocladia* spp. and *Plumaria.* The *Himanthalia* zone passes insensibly into the *Laminaria digitata* zone with a similar undergrowth. This level marks the limit of the littoral zone, but at extremely low tides, especially during quiet weather, the student may have an opportunity of penetrating into the *Laminaria Cloustoni* zone, where a search among the epiphytes clustering on the stems of the large Phaeophyceae will yield samples of many of the more delicate Rhodophyceae which have grown under optimum conditions.

The flora of this area will repay systematic visits at different times of the year as it shews well marked seasonal successions. (See section on Periodicity.) Examination of the flora in the spring or early summer will illustrate the lengths to which epiphytism may be carried as a consequence of successive invasion of plants into the area. One striking feature is the persistence with which *Lithophyllum* and *Corallina* are found as the basal layer in the successive " storeys " of vegetation. They may be completely overlaid and eventually quite hidden by superposed vegetation but a little investigation will reveal them, even though the bases of larger algae may spread over the initial coralline carpet. It would appear that non-coralline algae do not readily attach themselves to the bare limestone surface but it is not yet apparent by what means the *Lithophyllum* and *Corallina* overcome this difficulty.

The rocks fringing the harbour at Port St. Mary do not offer a luxuriant flora. Mud from the inner harbour disturbed by the tide appears to exercise a harmful influence. Nevertheless, a visit to the *Zostera* bed (Map II, 16) in search of epiphytes should be made. The beds can be reached via a flight of steps leading on to the shore from about the middle of the High Street.

Fleshwick Bay.

This part of the coast does not offer any type of algal vegetation that cannot be studied equally well in other areas, though the freshwater stream entering the bay frequently yields *Batrachospermum*, and patches of *Fucus ceranoides* on the shore owe their existence to the same stream. Amongst the Rhodophyceae to be found here may be mentioned *Catenella repens* which is very common in the crevices of the boulders. Until a few years ago this bay marked the extreme southern limit of distribution for *Odonthalia dentata* which is still to be found in some quantity in the low lying pools, but of late the plant has spread with some rapidity and is now to be found occasionally in all the bays of the survey area.

Fleshwick Bay is an excellent area for examination of cast-up material a day or two after a heavy storm, especially if the wind is from the north or west. The set of the currents round the coast is such as to bring the detached weeds in masses into Fleshwick Bay. Many of the inaccessible algae from the sub-littoral zone are thus made available to the collector. If an opportunity of dredging for algae presents itself, the algologist will be best repaid by turning his attention to the mouth of Fleshwick Bay.

Pooyllvaaish.

The rocky promontory at the northern end of Bay ny Carricky is an extremely good collecting ground for algologists. A rough cart track (Map II, 15), starting

from just beyond the cottage on the Castletown side of the point where the main road leaves the coast, leads directly seawards. It provides an easier means of access to the lower levels of the littoral zone than is afforded by a scramble over a considerable stretch of large boulders covered with *Ascophyllum*. On the right of the cart track as one faces the sea are a series of rock pools with a varied and interesting flora. In the summer time this is an excellent hunting ground for the rarer Rhodophyceae, such as *Monospora pedicellata*, *Griffithsia corallinoides*, *Spondylothamnion multifidum*, *Antithamnion cruciatum*, etc. In many of the deeper pools *Halidrys siliquosa* is well established as a perennial and yields a number of interesting epiphytes of restricted distribution. *Tilopteris Mertensii* and *Stictyosiphon tortilis* have been recorded for this locality alone and have not as yet been found in any other part of the survey area. An opportunity of collecting at the lowest of spring tides, especially in calm weather, or better still with a gentle off-shore breeze, could be employed more profitably in an examination of the low-lying levels of the shore at Pooyllvaaish than in any other part of the district.

CASTLETOWN.

The Castletown beach provides a type of shore in some respects similar to that of Pooyllvaaish. It is an excellent area for general collection in the springtime. The coast enjoys a certain amount of shelter and it has been noticed repeatedly that many of the Rhodophyceæ reach greater size and are of more luxuriant habit in the large shallow pools in the *Fucus*-covered littoral zone at Castletown than elsewhere. South-eastward towards Scarlet Point (Map II, 13) the land rises into terraces of limestone carrying an algal flora similar to that already described for Port St. Mary.

THE EFFECT OF ALTERNATING SEASONS ON THE ALGAL VEGETATION

To the casual observer the alternation of winter and summer brings little apparent change in the character of the algal population of the shore. This impression is largely due to the fact that the more obvious algae such as Fucoids and Laminarians are perennial plants. The algologist, nevertheless, is well aware that the number of genera and species represented in the flora is less in winter than in summer, and many of those species that do occur all the year round may be present in smaller numbers and in more restricted localities in the colder months of the year. Hence there is in reality a distinct fluctuation in richness of the flora as the seasons succeed one another, with a well-marked crescendo in the early summer accentuated by the influx of a large body of what have often been described, though sometimes without adequate reason, as "summer annuals."

Speaking generally, the poorest season for marine algae is in November and December. At this time of the year the algal population is at its lowest ebb though this does not necessarily imply that all growth and development is at a standstill. On the contrary, some of the Rhodophyceae (species of Polysiphonia, etc.) and certain erratic genera (Phyllitis) shew signs of more vigorous growth at this period than at any other. The general algal population, nevertheless, is reduced to its lowest terms as a consequence of partial depopulation of the shore during the autumn—a process brought about either by rough weather or by other inclement physical changes in the environment.

In the early spring, signs of general rejuvenation and re-colonisation of the littoral zone are observable. From February onwards there is a constant stream of new

arrivals first in pools and later on the general surface of the littoral zone as first one and then another member of the summer population makes its re-appearance.

Strictly speaking, in marine plant life, there is no hard and fast line to be drawn between "annuals" and "perennials"; distinct though these conditions may be when applied to land types. Indeed, neither term is applicable in its strictest sense to algal organisms.

Analysis of the data collected over an extended period shews that many algae, of which Fucoids and Laminarians are outstanding examples, are always to be found on the sea-shore. These plants are to be regarded as the nearest approach to perennials that can be found among British marine algae.

Another class of algae comprising many genera is made up of plants that are to be found in profusion over extended areas during the greater part of the year, with a high point of abundance in the early summer. To such a category belong many filamentous Phaeophyceae (Ectocarpus spp.) and many Rhodophyceae (Ceramium spp.). During the short intervening period representatives of these genera and species are still to be found, though in reduced stature and smaller number, in specially sheltered situations. These plants are therefore present throughout the whole of the year but form a less conspicuous element of the flora in the winter and may even escape observation altogether. Many of these genera and species have been described in older algological treatises as "summer annuals." Clearly they are not truly annual nor yet are they perennial for no individual plant lives for the whole of one season; indeed, its life-span is frequently limited to a few weeks, though the genus is maintained as a permanent component of the algal flora by successions of short-lived individuals. Such plants, whose numbers swell to a maximum in the summer but never quite reach

the vanishing point in winter, are perhaps best described as "pseudo-perennials."

Still another group of plants may be separated out from the rest, a group whose members are present, though not necessarily in abundance, for only a small proportion of the year, perhaps only during May, June and July; and which, despite careful search, are not to be found at all during the other months of the year. It is to such plants that the term "summer annual" may most legitimately be applied; though even here the term is used in a limited sense. This group includes such plants as *Nemalion multifidum, Dumontia incrassata, Chordaria flagelliformis, Mesogloia vermiculata,* etc.

These three groups—the perennial, the pseudo-perennial and the summer annual—contain genera and species with definite stations or zones of distribution to which they remain constant year after year and in which they are to be found in greater or less profusion according to the season.

A fourth group of plants may now be distinguished, whose occurrence is sporadic. These algae occur in small numbers or even as single individuals scattered here and there on the littoral zone. They are evanescent and there is no guarantee that having appeared in a given locality one year they will be found there the following year. Such plants are labelled "rare" in algal catalogues. Their presence in a list for a locality may rest on a single record and many years may elapse before another individual of the species is recorded for the same locality. These species may be described as "casual annuals." Associated with this group are also epiphytes or endophytes which are restricted to specific hosts, but are only of occasional occurrence. Sometimes the host plants show no signs of the dependent plants; at others they are thickly tenanted by the invaders. Such parasites are classed as "sporadic" in the systematic list.

PERENNIALS

Under this heading may be included a number of genera and species whose representatives always form a conspicuous plant-covering to considerable areas of the littoral zone or of the shore below low water mark. This vegetation may remain *in situ* in a given locality year after year. For example, a boulder beach formed of stones too large to be moved easily by the tide will usually bear a covering of one or another species of *Fucus*; while large boulders between tide-marks are constantly draped by *Ascophyllum nodosum*. The *Fucus* or *Ascophyllum* association is itself perennial but such a description can be applied only with reservations to the individual plants forming the association.

Longevity is not a well-marked feature of algal life. The vigour of the individual soon wanes, and it is doubtful whether on British coasts the span of life of even these so-called perennials exceeds two or three years. The permanence of the vegetation in contrast to the impermanence of the individuals is attributable to one or more of several factors :—

(*a*) The daily liberation of enormous numbers of reproductive cells extending over a long period (often several months).

(*b*) The ease with which the liberated cells attach themselves to the substratum and the readiness with which they germinate.

(*c*) The power of proliferation from truncated basal discs or attachment organs of various sorts.

The co-operation of these three factors is sufficient to maintain a constant supply of new plants to take the place of those that disappear.

Perennation in the sea is thus somewhat different from what one understands by perennation on land. Marine algae have no embedded parts, well stocked with

food material and protected by their underground position from the rigours of the unfavourable season. On the contrary, the whole of the plant is at all times exposed to the medium of sea-water and to the influences of physical forces affecting it. Some few algae do indeed inhabit situations where the rock surface is covered by sand or mud ;—for example, *Rhodochorton Rothii, Enteromorpha compressa,* etc., but in general the plants derive no special benefit from such a situation : on the contrary, movable sand is apt to imperil rather than safeguard algal life.

Within a marine environment there are always some plants which retain their power of growth throughout the year. On the British coasts, for example, at all times of the year one can find sporelings of *Fucus* in various stages of development scattered over the littoral zone. Many of them have started life in positions where they will never succeed in establishing themselves as mature plants, but the frequency with which one encounters these hardy young plants well outside their normal fucoid zone, indicates the ease with which liberated *Fucus* eggs will germinate, and argues that the alternating climatic conditions of winter and summer on these coasts do not materially affect the growth of Fucoids and other algae indicated in the list of perennials. Tolerance of these plants for a wide range of fluctuation in environmental conditions renders them, as far as growth is concerned, more or less indifferent to the seasons.

This conclusion is supported by the ease with which proliferation from basal parts takes place after removal of the upper part of the frond. One frequently sees evidence of this in the *Fucus* zones. New apices are readily regenerated and new branches produced matching their predecessors in stature and elegance. Nevertheless, this regenerative process is not capable of indefinite repetition The individual at last loses its vitality and

remains as a decapitated disc, serving only as a locus of attachment for plants of other genera. In the immediate neighbourhood of these relics may be found, in all probability, a flourishing crop of young plants—the progeny of the destroyed parents.

Some genera of the *Fucaceae* show a biennial habit. The young plants make vegetative growth during the first year and defer the formation of conceptacles until the next year. This is the case with *Himanthalia lorea*. In the autumn thousands of minute "buttons" adorn the crevices and irregularities of the rock surface in places where this alga grows (Plate I). Side by side with these infant plants are other "buttons," one year old and already full grown, from whose centres may be seen sprouting an inch or two of strap-shaped receptacle. Nearby may be found plants of two years' growth with fully developed receptacles bearing a load of epiphytes whose increasing weight will eventually accelerate the destruction of the *Himanthalia* host.

The simultaneous occurrence of *Himanthalia* buttons of all ages indicates that vegetative growth can be carried on independent of the march of the seasons. The above statement will stand for all algae included in the list of perennials. It must not be supposed, however, that perennial plants are entirely insensitive to the alternation of physical conditions throughout the year. The periodicity of seasonal change is reflected in the production of reproductive organs at one specific season of the year. It is interesting to note that even for allied genera and species the same season is not necessarily selected for reproduction. The Fucoids, for example, show among their genera considerable diversity in their times of reproduction. *Ascophyllum nodosum* reproduces from February to May with a high point of fertility in April. *Fucus vesiculosus* follows, beginning in April and rising

to a maximum in May and early June, though fertile individuals may be found much later. August marks the maximum reproductive period for *Pelvetia canaliculata* whose antheridial conceptacles may be so numerous as to paint an orange stripe visible some distance away, round the cliffs at high water mark. *Fucus serratus* prefers the autumn for reproduction and plants with plentiful receptacles may be found throughout the winter.

Clearly there must be for each genus in its appropriate season some co-operative influence of all the effective factors of the environment, stimulating the plant to copious reproduction. For Fucoids and Laminarians and some other genera, reproductive structures are confined to special limited portions of the thallus : in other cases reproductive organs are produced all over the plant surface. The initiation and nourishment of these cells must tax the resources of the plant to the uttermost so that when large numbers of them filled with food material have been liberated, there is left behind a depleted thallus whose surface, ruptured to allow the escape of generative cells, now offers itself a prey to colonisation by the spores of epiphytic genera. When reproductive cells are liberated in successive crops extending over a long period of time, it is obvious that the expenditure of energy involved and the amount of accumulated material dissipated must eventually bring about complete depletion of the plant's vitality and lower its resistance to the forces tending to destroy it. Of the latter, the most effective is undoubtedly the strain of moving water, and when, as frequently happens, periods of rough weather coincide with the period of maximum reproductive activity, the result is the tearing of thalli and their removal on a wholesale scale.

The fact that depopulation is quickly made good by an upgrowth of sporelings or by proliferation from basal

parts indicates that for many genera there is nothing inhibitive to growth in the conditions governing any season of the year. But new growths require a certain time to attain maturity, hence there is observable a seasonal fluctuation in mass, attributable not to any direct effect of the environment on growth, but indirectly to the precipitation of reproduction on a large scale at one specific season of the year.

All that has been said above about large algae such as Fucoids and Laminarians applies equally well to a host of smaller genera. Such plants as *Laurencia hybrida, L. pinnatifida*, and species of *Chondrus, Gelidium, Gigartina* and *Rhodymenia* have a wide range of distribution on the shore and come under the category of " common " algae. In the autumn these plants are considerably depleted in numbers or suffer decapitation and are represented in the early winter months by their basal parts only, sometimes reduced to a small disc less than a third of an inch in diameter. This relic is firmly adherent to the substratum and is capable of sprouting vigorously into new shoots in early spring. An illustration may be drawn from the behaviour of *Laurencia hybrida* on limpet shells in pools on the limestone terraces at Port St. Mary. In the autumn, this area is subject to a considerable amount of scour, when many of the *Laurencia* fronds are removed. In January an examination of the limpet shells in this area revealed the presence of numerous bases of *Laurencia* plants hidden amongst a covering of *Sphacelaria cirrhosa* (short, tufted, winter form). In February these basal discs had already begun to proliferate from the margins and showed a new growth of fronds nearly an inch long and already bearing antheridia.

If definition of the term perennial implies merely a capacity for withstanding an unfavourable season, then these *Laurencia* plants are perennial. This, however,

is not quite the end of the matter. It is not known, for example, what proportion of the plants remain as persistent bases; nor how many times this regenerative process may take place in the life of one individual. Young sporelings are constantly developing alongside their mature relatives and are ready to fill in the gaps. It is difficult therefore to estimate with precision the length of life of one plant.

Moreover, the matter is somewhat complicated by the fact that many genera show not one but two periods a year when new thalli arise; one in the early spring and a second in the autumn. The spring plants reach a reproductive stage in the early summer and may then become submerged under a profuse development of other genera. They persist as somewhat debilitated plants for a time and then die off or remain only as basal attachment organs. Meanwhile the autumn crop of vigorously growing plants—probably the progeny of the spring crop—becomes conspicuous in September and October. Some may reach a reproductive stage but the plants developing late in the season may fail to do so, and remain in a vegetative condition over the winter. The renewal of activity of these plants and the development of sporelings are together responsible for the next spring crop.

Pseudo-Perennials

It is somewhat difficult to draw a distinction between this class and the preceding one, for if the proportion of persistent bases falls to a low figure, continuity of the species in the flora is maintained largely by the upgrowth of young sporelings and the plants cannot be classed as perennials: neither are they truly annuals but for convenience have been called "pseudo-perennials." Under this heading have been included a number of species with a peculiar behaviour. The power of regeneration of

new thalli from persistent bases has already been remarked; there exists also the possibility of regeneration from small detached portions of fronds—fragments of small size but still endowed with sufficient vitality and vigour to enable them to re-attach themselves to the substratum and produce a whole new thallus. In the autumn large masses of plants become torn from their hold and pounded into fragments, many of which remain alive for days, and during their diurnal pilgrimage with the tide up and down the shore, may eventually find harbourage in quiet water or lodgment on tiny crevices, on the surface of shells or become entangled among the thalli of more resistant algae. The relics very soon put out attachment organs, anchor themselves to the substratum and so begin a new phase of existence in a locality perhaps far removed from that in which their first youth was spent. Regeneration from floating fragments thus plays a part, though perhaps a minor one, in maintaining continuity of algal vegetation on the shore. It has been observed that genera and species employing this method most successfully are those whose attachment organs take the form of rhizoidal outgrowths from superficial cells. Among such plants are many of the common species of Polysiphonia, Ceramium and Callithamnion.

A remarkable illustration of the points just raised is provided by the study of the "limpet island" flora of the limestone flats of Port St. Mary. Here saucer-shaped pools varying in depth from a few inches to a foot or two carry a fairly rich summer vegetation. Underlying the plant community is a carpet of *Lithophyllum Lenormandi* (Plate III) which forms in the upper pools a conspicuous covering not unlike a very thick and somewhat lumpy coat of pinkish white enamel. Round the edges of this floor covering and wherever the substratum or the *Lithophyllum* surface gives ready anchorage arise tufts of a very stunted

form of *Corallina officinalis.* These plants in their turn provide a locus for the attachment of a host of other genera (Plate VII). As week succeeds week new arrivals attach themselves to the plants already present until in the summer the strata of epiphytes may be five deep. During the winter the population of these pools suffers great denudation. Everything is removed except the broken and stunted remains of the *Corallina ;* even the surface of the *Lithophyllum* looks as if it has been planed down to a minimum basal layer. Limpets in these pools stand up as minute conical islands and suffer denudation less severely than the surrounding plane surfaces. Microscopic examination shows that the limpet shells are covered by the basal remains of a large number of plants and that there are also small fragments of thalli of various genera ; these have put out rhizoidal attachments and anchored themselves in the interstices of the shells. During the depth of the winter when nothing may be showing in the upper pools except debilitated *Lithophyllum* and *Corallina,* the limpet islands may still bear a comparatively varied though not luxuriant flora. It is noticeable that the genera found in such situations are all plants provided with a spongy or fibrous system of attachment organs ; just the type that can most easily attach itself to the ridges and furrows of the limpet shells. Microscopic investigation of the limpets also reveals numerous minute sporelings in various stages of development, representing genera and species not in evidence in the pool flora except on the limpet shells. These genera and species may, however, be found lurking in pools at deep water level or as stunted plants in sheltered situations. The limpet island flora therefore represents relics of an autumn migration that sets seaward at the onset of unfavourable conditions. Development of this relic flora takes place early in the

year. In February and early March the pools about the half-tide zone may be still in the denuded winter condition but tufts of vigorously growing algae crown the heads of the limpet shells. These now serve as centres of distribution bringing about the rapid recolonisation of the pools in the early summer.

Annuals

Under this heading are included genera with a restricted vegetative period or those that appear sporadically; the distribution of which varies markedly from summer to summer. These plants disappear completely at the end of the favourable season and cannot be accounted for by the persistence of fragments or of plant bases. Their re-appearance must be brought about by the liberation and subsequent germination of propagative cells of one sort or another. These plants are more strictly annual than any discussed above.

In the absence of thick-walled resting spores (not produced by marine algae except perhaps by marine *Vaucherias*) it is difficult to conceive of a delicate unprotected unicell suffering the buffeting of the tides for five or six months and remaining capable of settling down, attaching itself to the rock and reappearing in recognisable form in the same locality where its predecessors had flourished. It must be a *sine qua non* that the reproductive cell attaches itself to the substratum very shortly after its release. The question to be answered is, therefore, to what extent does it develop in the autumn and in what form does it exist over the unfavourable period? An undeveloped spore or even a plantlet of two or three cells would have little chance of survival against the depredations of browsing crustacea whose habit is to clean up any surface over which they progress. It seems more probable that the spores released in the autumn develop

into minute cellular plantlets large enough to be resistant to forces tending to destroy them, possibly sheltered in tiny crevices of the rock, and ready with the return of Spring to develop into macroscopic plants.

Just as in land plants there may be several crops of annuals in one growing season, if the life-cycles can be achieved in sufficiently short space of time, so, in the sea, the annual summer vegetation may really consist of large numbers of successive generations, rising to maturity and capable of reproduction in a very short space of time In the autumn, germination of released zoids takes place more and more slowly until finally the growth of the germling is so slow as to be quite imperceptible and the plantlet rests in a condition of protracted infancy until the following spring.

Large numbers of filamentous forms and even genera of more ambitious organisation behave in this way. This method of existing through an unfavourable period is characteristic of summer Rhodophyceae, such as species of *Nitophyllum*, *Bonnemaisonia*, *Callithamnion*, etc., and of many Cladophorae and other Chlorophyceae. The Phaeophyceae behave in a somewhat different manner and will be dealt with in a later section of the memoir.

The constancy of these annuals in the flora is due to the fact that they produce propagative cells in large numbers; the latter are sown broadcast over the littoral zone and on the substratum below low tide level and, being hardy, germinate in large numbers. Many of the plantlets are doomed to failure but those in an appropriate environment will readily replace their parents in the next summer population.

Casual Annuals

Casual annuals are only distinguished from "annuals" by the fact that they rarely occur. They are for the

most part species that have strayed from their geographical area of distribution and, finding conditions generally somewhat unfavourable, are not successful in establishing themselves as constant components of the flora. The reproductive cells, though often produced, may find germination exceedingly difficult ; hence it is only an odd individual that succeeds in surmounting the rigours of the winter and reaching maturity in the following summer. *Stilophora rhizodes* will serve as an example. Naturally a member of a more southerly flora it is represented in the British flora of the South Coast and has been recorded for stations all round the coast of the British Isles, including the extreme North, but the Isle of Man record for the plant refers only to Port Erin, and as far as we are aware no specimen has been found during the last eighteen years.

One of the striking features brought out by a study of periodicity among marine algae is the readiness with which reproduction occurs. In the early spring it is quite common to find specimens of *Polysiphonia, Ceramium* or *Callithamnion* bearing antheridia or tetraspores on thalli that are barely half-an-inch long. Later in the spring, vegetative growth is carried still further before reproductive cells are formed, so that sterile plants two or three inches or even longer may be found. At the height of the growing season the limits of size achieved before reproduction takes place are still further extended. The co-existence, side by side, of fertile and sterile plants, argues that the formation of reproductive cells is not necessarily a direct result of the physical factors of the environment but is associated in some obscure way with internal factors ; the net result of the combined internal and external forces being the precipitation of reproductive processes as the culmination of the plants' activities,

following a period of vegetative growth, greater or less according to the period of the year.

As the vegetative period is extended the total mass of thalli of plants of one species naturally increases, so that when reproduction does occur it results in an increasing number of propagative cells at every successive crop. The proportion of the latter achieving successful germination also rises with the advancing season, thus accounting for the marked influx and sometimes overwhelming mass development of individuals of a given species in a particular area. The high point of this crescendo movement may be sharply defined. The beaches may be strewn in autumn with hundreds of plants of certain annual species, each in full reproduction, especially if a protracted period of rough weather supervenes in the early autumn. Within the space of a fortnight individuals of the species in question may almost entirely disappear. The change in physical conditions culminating in the autumn thus not only suddenly exercises a deleterious effect on mature thalli but also markedly retards the germination of sporelings which thus remain dormant until the following spring. Such is the behaviour of most annuals.

On the other hand, for some species, autumn conditions may be gentle in their operation so that a gradual diminuendo period follows that of maximum development. As the autumn weeks succeed one another, individuals of a given species occur less and less frequently ; they are smaller and smaller in stature and may not readily achieve reproduction. Even during the winter, however, individuals here and there may still persist in sheltered places and small fragments may readily re-attach themselves. These characteristics most usually distinguish the pseudo-perennial. Thus the characteristics distinguishing the perennial, the pseudo-perennial and the annual algae are

seen to be differences of degree rather than of kind. Segregation of species into different categories is based on the following criteria :—

(*a*) The extent of thallus destruction in the autumn.

1. Thallus only partially removed. Reproduction by sporelings and proliferation from basal parts of plants equally effective in producing new plants. *Perennials.*
2. Thallus almost completely removed. Majority of new plants due to development of sporelings but proliferation from basal parts or from re-attached fragments also common. *Pseudo-perennials.*
3. Thallus entirely destroyed. New plants due entirely to the development of sporelings. *Annuals.*

(*b*) The extent of the growing period.

1. All the year through. *Perennials.*
2. The major portion of the year. *Pseudo-perennials.*
3. A restricted period in summer (or winter). *Annuals.*

ALGAL MIGRATIONS IN THE LITTORAL ZONE

From what has been said above it is clear that the algal population of the British coasts shows a certain periodic amplification and diminution corresponding to the alternation of summer and winter seasons. The direct effect of seasonal changes is felt less by perennials than by other classes of algae but rough water may be destructive of perennials, pseudo-perennials and annuals alike so that during the late summer numbers of plants may be detached and cast up. Autumn is frequently rendered conspicuous by the enormous masses of weed

lining the beaches. The cause of this wholesale destruction is not a simple one. A good many factors co-operate to bring it about. In large measure it is the penalty of success. Competition for foothold is a great factor in algal life, and when rock surfaces are already occupied to full capacity, new comers must find room on the surfaces of previously established thalli. A second influx of germinating sporelings adds another storey to the superstructure and so on, the stability of the whole resting on the tenacity of the ground-floor tenant, so to speak. The original vegetation is eventually buried under an increasing load of epiphytes and, deprived of necessary illumination, possibly also of adequate oxygen supply, it becomes merely a question of time before the increasing leverage of moving water acting on a deteriorating thallus with a burden of supernumerary organisms proves too much for the elasticity of the plant tissues. Large quantities of detached weed are then thrown up on the shore and find a useful end as manure, contributing their mineral content to the furtherance of plant life on land.

It would seem therefore that part at least of the autumn depopulation is attributable to keen competition for foothold on a limited area of the shore and to mutual interference of the components of a too profuse flora. Nevertheless, the foundation of this annual rise and fall of algal vegetation rests on the difference in physical factors between one season and another.

The Factors

Fig. 1 is a graphic presentation of the mutual relations of mean monthly sea and air temperatures. It is based on the record of temperature data collected during twenty-five years, from 1903-1927, at the Marine Biological Station, Port Erin. Scrutiny of the figure shows that

mean temperatures for air are less than those for the sea during the period from September to March, but exceed them during the summer months. There are thus two points—early April and late August, when mean temperatures for sea and air are approximately equal.

Temperature variation is, however, by no means the most potent factor controlling algal activities. It is difficult to dissociate the influence of rising temperature and of increasing insolation, for as a rule both factors show variation in the same direction at the same time. In the spring, however, when the rate of algal growth undergoes sudden acceleration it is probable that the rising value of incident light involving increased length of daylight as well as of greater intensity of illumination, acts as the stimulating factor, for a scrutiny of temperature records (Fig. 1) shows that no very great rise in the temperature of the sea-water takes place until late in the spring, long after the growth acceleration has shown itself. The somewhat higher air temperatures in the late spring do not play any great part in encouraging algal activity since the most marked growth appears in the lower third of the littoral zone, amongst algae that are not exposed for long periods to the air. On the other hand, rising air temperatures of high summer acting on algae during periods of long exposure or affecting the temperature of pools at high levels on the shore, may reach a point that exceeds the range of toleration of many species inhabiting the littoral zone. Co-operating with this rise in temperature are increased exposure to illumination, enhanced risk of dessication, and increase in the salinity and in the pH of the pools, during the periods when exposure occurs in the middle of the day.

From the data collected one would suspect that temperature and insolation together are limiting factors in the summer time. With these factors must also be considered

the diminution of available nitrates and phosphates in sea-water which, as Atkins, Harvey and others (Publications from the Marine Laboratory, Plymouth) have shown, takes place progressively in the autumn. But the supply of nitrogen is soon replenished by the decay of organic material, especially following the fall in plankton

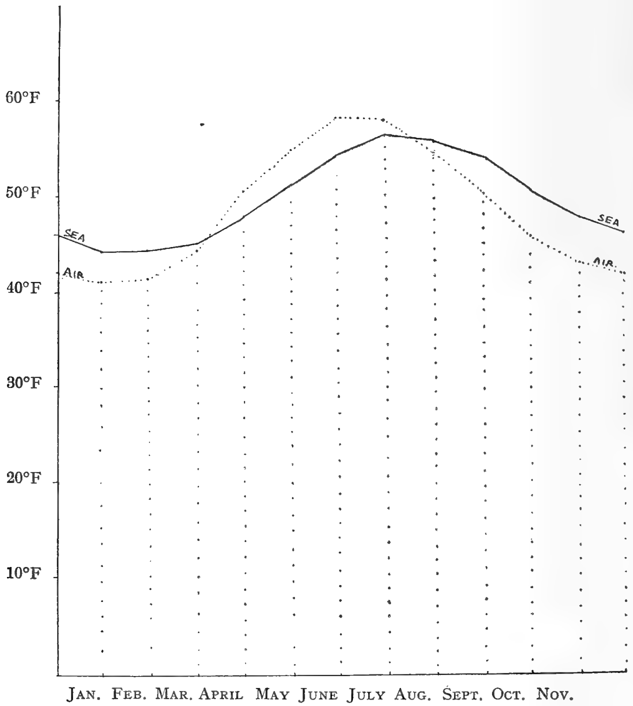

FIG. 1. Mean Monthly Temperatures of Sea and Air for 1903–1927.

content in the autumn, and also by the upwelling of supplies from deeper water. The scarcity of available food supply, therefore, may intensify the unfavourable physical conditions of the autumn and prove the last straw to the resistance of thalli already impoverished by other causes, though it is unlikely that this factor has a prolonged

influence on the vegetation in the winter. It is much more probable that the controlling factors in this season are the varying effects of light and temperature. From the foregoing it is clear that many factors play a part in controlling the algal population of the shore. It would appear that rising temperature and brighter light at first encourage algal growth, provided that adequate nutrient salts and dissolved gases are available, but the limits of variation in an upward direction for both temperature and insolation are soon reached. This is proved by the fact that in more southerly latitudes the grand period of algal growth falls earlier and earlier in the year, until in the Mediterranean region optimum conditions for algal growth occur in the winter and early spring, while summer forms a "dead season."

Periodic observations have shown that during the autumn, individuals of certain species with a wide bathymetric range tend to disappear from the upper levels of their area of distribution, but may be found in quantity in lower levels where they were formerly not so prevalent. This downward migration may be continued until in the height of the unfavourable season individuals of the species in question may still be found in sheltered places in the low-lying levels of the shore but are absent, at all events in macroscopic form, from the middle and upper zones. Dredging or examination of the "cast-ups" after a sudden storm will reveal the presence of these deep water survivors.

The explanation of this "migration" may lie in the fact that physical conditions of upper pools, offering as they do a greater amplitude of variation when compared with the pools at lower levels, automatically become unsuitable habitats for the development of a given species. Released spores will therefore either fail to germinate or will grow only into a microscopic winter form

and the species "disappears" from the flora of the upper pools, though it may still be flourishing in pools further down the shore. Later on adverse conditions may affect successively deeper lying pools, so bringing about what appears to be a "migration." In the following spring the procession of macroscopic plants follows the reverse order and appears to rise from level to level as spring merges into summer.

Many species of Rhodophyceae (*Rhodomela subfusca*, *Delesseria* sp.) and some Chlorophyceae undergo this seaward migration in the winter. The pools about high water of neap tides are characteristically green in summer. Many of them are inhabited exclusively by species of *Enteromorpha*, *Ulva*, *Cladophora*, *Rhizoclonium* and *Chaetomorpha*. During the winter this well-marked zone is almost obliterated and representatives of the genera in question are to be found at much lower levels—in the mid-tide area for example. The behaviour of *Cladophora rupestris* may be most marked; in September it forms, on the limestone terraces of Port St. Mary, a well-marked zone several yards in depth at a distance of 50 yards (representing a drop in level of 12 feet) from high water of neap tides. Observation of this zone in January shows that the plants are worn down to their bases or completely removed and the well-marked zone of September was scarcely detectable, though large numbers of plants actively growing and already reproducing were to be found further down the shore nearer to low water mark. The zoids from the plants in this area are doubtless responsible, together with proliferation from basal remains, for the re-establishment of the mid-tide *Cladophora rupestris* zone in the early summer.

The direction of these migrations is not always as outlined above, for there are many species whose movements are in exactly the opposite direction. They are

to be found in lower pools in the summer and gradually spread upwards during the winter to form a conspicuous component of pools at much higher levels. The behaviour of *Dumontia incrassata* or of *Scytosiphon lomentarius* will illustrate the point—the latter being a well-marked component of the littoral zone. In the summer months it achieves optimum development about the mid-tide zone. The most luxuriant specimens die away towards the end of September but small individuals often without characteristic constrictions make their appearance at or near high tide mark and may be found there in large numbers, often without admixture of other algae, long after their fellows have quite disappeared from the lower levels of the shore. For some time these winter plants remain sterile, but in January and February they shew renewed activity of growth and reproduction and act as a source of " infection " of all neighbouring pools. The successive generations now work downwards from the upper part of the shore towards low water level ; at the same time the plants become successively larger and more luxuriant ; they also reproduce readily. As the summer advances the upper pools become uninhabitable and the Scytosiphon plants die out from these levels during the months of July and August but re-appear in the autumn. There is thus, so to speak, a seasonal tide of Scytosiphon plants moving rhythmically from higher to lower levels of the shore and back again in the span of one year. This migratory habit of *Scytosiphon lomentarius* is shared by other genera present in the flora throughout the whole year but appearing in different parts of the shore in different seasons. A comparative study of the flora of the limestone terraces of Port St. Mary at different times of the year has shown that many Rhodophyceae, especially species of *Polysiphonia, Ceramium, Callithamnion* move upwards during the winter. In January

the upper limit of their distribution may be 30 yards higher up the shore than in September, corresponding to a rise of 8 feet in a vertical direction.

Migrations such as have been described above also take place in pools if the volume and depth of the pool be sufficiently large. The following observations were made on the movements of *Asperococcus fistulosus* in a large pool on the shore at Port Erin. The pool in question lies rather high up on the shore but is about five feet deep at the seaward end where it is also protected by upstanding rock ridges from too great insolation. Landward it shallows markedly, its depth decreasing to a few inches. The sides are for the most part vertical and though the pool is distinctly above the zone of red seaweeds on the surrounding shore, many members of the Rhodophyceae find suitable habitats on its shaded sides. The total length of the pool is ten feet and its breadth five, offering an excellent opportunity for observation of periodic changes in the algal flora. *Asperococcus fistulosus* plants are to be found in January and February only in the well-lighted shallow end of the pool where they appear to take advantage of the best illuminated positions. The plants are small, slender and show only occasionally the irregularity of outline typical of normal plants. They are usually provided with plurilocular sporangia only and are now regarded as the winter form of *A. fistulosus,* though at one time it was suspected that they might be a distinct species or at least a variety. The view now held is that they merely represent a seasonal growth form of the plant. In March these plants show no great increase in number and appear to be less flourishing than formerly though other and more robust plants—presumably the progeny of the first-comers—now make their appearance in a position about half-way between the shallow and the deep ends of the pool. These latter

plants do not grow at the surface but appear as epiphytes on other algae growing on the sides of the pool at a depth of about a foot. One gains the impression that the factors controlling conditions at the shallow end of the pool are no longer favourable to the growth of *Asperococcus fistulosus*. Still later in the year, during the summer months, the plants disappear from the median position and are only to be found near the bottom of the pool at the deep end, where illumination is diminished and where the temperature is less subject to daily rise by insolation. This localised movement of Asperococcus within the confines of one pool is paralleled by the movements of the plants on the open shore. In the winter *Asperococcus fistulosus* is to be found only as meagre individuals in shallow well-lit pools of the upper zone. It relinquishes this position in the spring and appears as a component of the flora of pools much lower down the shore where the shorter period of daily exposure counteracts the increasingly strong spring sunshine. The downward migration is continued until Asperococcus is to be found as an inhabitant of pools lying at the level of ordinary neap tides.

The factors determining these migrations are difficult of analysis. It would appear that a falling value for light intensity is not the imperative factor for plants that move downwards during the winter since a move in such direction leads to further diminution of the already reduced autumn and winter daylight. Neither is scarcity of mineral salts likely to cause migration since the work of Harvey, Atkins, and others has shown that the nitrate and phosphate content of sea-water though depleted in the autumn is replenished in the winter. The factor that suggests itself as being directly concerned with these migrations is that of changing temperatures. In the summer the air temperature rises above that of the sea,

consequently pools left longest exposed to the air will reach a higher temperature than others. Conversely the air temperature in the winter falls distinctly below that of the sea, so that the upper pools will again be the ones to show the greatest range of variation. There is therefore a graduated scale of temperature observable on any sector of the shore with the highest values in pools at the high tide level and a minimum value, equivalent to that of the general sea temperature, in pools at low water mark. The intervening pools will shew intermediate temperatures determined partly by their distance from the low water mark and partly by the physical proportions of the pools themselves—shallow pools being subject to greater temperature rise than deep pools during the same period of insolation. Moreover, a deep pool may shew well-marked layering of water at different temperatures. The upper surface under the influence of insolation may rise in temperature but, if no mixing of the waters from below occurs, the warmer and therefore lighter water will remain floating on top. A difference of three degrees between surface water and bottom water may be observed in summer in a pool that is no more than eighteen inches deep.

In the winter the temperature gradient may be reversed in direction. The lowest temperature will be experienced by the algal flora of the upper pools. It follows therefore that spring and autumn constitute critical periods for the algae, literally turning points in the current of invasion. In an interesting way this temperature factor serves to discriminate genera and species according to their preference for certain conditions and determines the direction of their seasonal migrations from level to level on the shore. Plants with a preference for warmer conditions will move down the shore in the winter and re-ascend to higher levels in the following spring.

The movements of algae *up* the shore in the winter are probably accounted for by the diminished light of the autumn and winter. Many Rhodophyceae are among the plants that migrate in this manner and being somewhat sensitive to the strength of illumination falling on them can only spread upwards during the period of diminished insolation. In the spring the rising values of the incident light act as a limiting factor to the upward movement and the high values of summer insolation may actually cause the death of plants in the upper levels of their area of distribution. Another factor may also take a prominent part in the summer zoning of the algae, namely the change in pH of the pools subject to great insolation. The pools at the upper limits of the tidal zone with an exclusively green algal population frequently show pH values as high as 9·6. Such conditions encourage the growth of Chlorophyceae but prove unsuitable habitats for the growth of Phaeophyceae and still more so for Rhodophyceae.

It has been shown that periodicity in algal activity is controlled by the physical factors consequent on life in a moving medium and also by physiological changes in other factors of the environment. The factor that limits the advance of a genus is not necessarily also a limiting factor for other genera or even for other species of the same genus. Nor is the proportionate influence of component factors the same for all plants; nor is it constant for one plant at all times of the year. Whatever be the relations between an alga and the component factors which together make up its environment, the onset of unfavourable conditions is inevitably heralded by copious reproduction; the last act of the threatened vegetation is the production of propagative cells, just as the formation and maturation of seed marks the finale in the annual life-cycle of the land plant.

THE SYSTEMATIC LIST

The systematic list of algae has been compiled during the past ten years by periodic collection from five points in the south-west corner of the Island, namely:—Port Erin, Port St. Mary, Fleshwick, Castletown, and Pooyllvaaish. The nomenclature and system of classification here adopted is that established by Batters (1902) in his "Catalogue of the British Marine Algae," but where the author of the catalogue has made alteration in a name long familiar to algologists, the older name is introduced in brackets. In certain instances Batters' naming of a species has been revised by Mr. A. D. Cotton (1912) in his report on marine algae in the Clare Island Survey. The revised names have been adopted here.

The present list is in part an amplification of several previous lists, to which has been added a considerable body of new data accumulated during the past few years by various workers who have visited the station from time to time, and by the authors themselves who have collected regularly throughout several years over the five collecting grounds.

The only comparatively recent list of the algae of the Island is one compiled by Harvey-Gibson, Knight and Coburn (1913) and published in the "Transactions of the Liverpool Biological Society." The list in question includes the names of all algae found by the authors themselves or occurring in the scientific papers of previous collectors (Bradley, 1861; Garner, 1867; Gatty, 1872; King, 1889; Marrat, 1863-4; Talbot, 1890). Where species have been recorded but not seen by the authors the authority for the record is given in brackets. The present authors have adopted the same policy.

Since the publication of the 1913 list the recorded number of species in the algal flora of the Island (exclusive

of blue-green algae and Diatoms) has risen to 349,—a number that exceeds the 1913 census by 99. The new species are indicated in the following list :—

NEW SPECIES ADDED SINCE 1913.

CHLOROPHYCEAE

Prasiola stipitata Suhr.
Capsosiphon aureolus Gobi.
Codiolum gregarium Br.
C. petrocelidis Kuck.
Pringsheimia scutata Rke.
Monostroma Grevillei Wittr. var. *Cornucopiae* Batt.
Monostroma Wittrockii Born.
Enteromorpha torta Reinb.
E. micrococca Kütz.
Ulothrix implexa Kütz.
Endoderma viride Lagerh.
Endoderma flustrae Batt. var. *Phillipsii* Batt.
Urospora collabens Holm. et Batt.
Chaetomorpha crassa Kütz.
Rhizoclonium Kerneri var. *endozoica* Wille.
Cladophora fracta Kütz, var. *flavescens* Batt.
Gomontia polyrhiza Born. et Flah.
G. manxiana Chodat.
Vaucheria Thuretii Woron.
Codium amphibium Moore.
C. adhaerens Ag.

PHAEOPHYCEAE

Mikrosyphar Polysiphoniae Kuck.
Litosiphon filiformis Batt.
Stictyosiphon subarticulatus Hauck.
S. tortilis Rke.
Punctaria plantaginea Grev.
Asperococcus bullosus Lamour.
A. compressus Griff.
Streblonema fasciculatum Thur.
S. infestians Batt.
S. Zanardinii Batt.
Ectocarpus parasiticus Sauv.
E. brevis Sauv.
E. luteolus Sauv.
E. microscopicus Batt.
E. tomentosoides Farlow.
E. velutinus Kütz.
E. simplex Crn.
E. ovatus Kjellm, var. *arachnoides* Rke.
E. confervoides Le Jol forma *typica* Kjellm.
E. fasciculatus Harv. var. *refracta* Ardissone.

E. fasciculatus Harv. var. *Draparnaldioides* Crn.
Arthrocladia villosa Duby.
Myriactis pulvinata Kutz.
Elachista flaccida Aresch.
Leptonema fasciculatum Rke, var. *majus* Rke.
Colpomenia sinuosa Derb. et Sol.
Sphacelaria bipinnata Sauv.
Halopteris filicina Kütz, var. *sertularia* (Bonnem.)
Myrionema aecidioides Sauv.
Myrionema saxicola Kuck.
Myrionema strangulans Grev. var. *punctiforme* Holm. et Batt.
Ulonema rhizophorum Foslie.
Hecatonema maculans Sauv.
Ascocyclus saccharinae Cott.
Lithoderma fatiscens Aresh.
Chordaria divaricata Ag.
Aglaozonia reptans Crn.
Dictyota dichotoma Lamour, var. *implexa* J. Ag.

RHODOPHYCEAE

Erythropeltis discigera Schm. var. *flustrae* Batt.
Erythrocladia subintegra Rosenv.
Porphyra coccinea J. Ag.
P. linearis Grev.
Colaconema reticulatum Batt.
Acrochaetium endozoicum Batt.
A. emergens Rosenv.
Helminthora divaricata J. Ag.
Scinaia furcellata Bivona.
Choreocolax Polysiphoniae Reinsch.
Harveyella mirabilis Schm. et Rke.
Pterocladia capillacea Born.
Gelidium pusillum Le Jol.
G. pulchellum Kütz.
G. latifolium Born.
Sterrocolax decipiens Schm. (see note 15)
Rhodymenia palmata Grev. var. *marginifera* Harv.
Nitophyllum uncinatum J. Ag.
Nitophyllum ramosum Batt. var. *uncinatum* Grev.
Polysiphonia spinulosa Grev. var. *major* J. Ag.
Trailliella intricata Batt.
Ptilothamnion pluma Thur.
Halurus equisetifolius Kütz.
H. equisetifolius Kütz. var. *simplicifilum* J. Ag.
Callithamnion scopulorum Ag.
Callithamnion Dudresnayi Crn.
Callithamnion Brodiaei Harv.
Monospora pedicellata Sol.
Antithamnion cruciatum Näg.
A. plumula Thur.
Ceramium strictum Harv.

Ceramium botryocarpum Griff.
Dudresnaya verticillata Le Jol.
Melobesia farinosa Lamour.
Melobesia corallinae Solm.
M. minutula Foslie.
Lithophyllum incrustans Foslie.
Lithothamnion colliculosum Fosl., var. *rosea* Batt.
L. lichenoides Fosl. var. *agariciformis* Fosl.
Corallina squamata Ellis.

It will be seen that the new records include a number of microscopic species whose absence from previous lists is no doubt due to lack of critical microscopical examination. Many of these species are endophytes or epiphytes of minute stature ; some were previously regarded as the reproductive phases of the hosts on which they live and only recently have been raised to the dignity of independent genera.

The macroscopic additions are not without interest. The inclusion of some new names in the list is doubtless due to the fact that new areas have been laid under contribution. *Monospora pedicellata* for example, is locally abundant at Pooyllvaaish, but has not been recorded elsewhere in the Island. It is probable that as the field of operations is gradually extended to include all the small bays that indent the coast, the names of other locally restricted species may be added to the list.

This explanation does not, however, suffice for all the newcomers. It is believed that there have been real additions to the flora of the Island. A few years ago, *Colpomenia sinuosa* made its appearance on the Castletown coast (see Cotton, 1908, 1911). It was then represented only by occasional individuals ; but within the space of five years, it has spread so widely that it is now a common component of the summer flora in the littoral zone in four of the collecting areas.

Other plants whose frequency on the shore has shown marked increase of late are *Calliblepharis lanceolata, Halurus*

equisetifolius, Pterosiphonia thuyoides and several species of *Ectocarpus*. The influx of these algae does not appear to be merely a phase of frequency-variation, controlled by physical conditions in any one season, whereby the plants may be common in one year and only of occasional occurrence in the next ; rather does it represent a steady forward movement continued over at least ten years, by which the area of distribution is widened and at the same time the frequency of occurrence within the area is raised.

The question naturally arises as to why floristic variations of this type should occur. Scrutiny of the newly-added names shows that the majority of the larger forms are plants occurring commonly at points widely distributed on the British coasts. The Isle of Man is therefore well within their area of distribution. Its insular position may have delayed the appearance of these species on its coasts ; but as soon as chance immigration occurs, it is only a matter of time before the species in question become well-established components of the Manx flora.

Standing as it does midway between north and south of the British Isles, the Isle of Man occupies the border-line between northern and southern floras, with the result that such northern plants as *Odonthalia dentata* and *Euthora cristata* exist side by side with typical southern forms such as *Spondylothamnion multifidum*. Many of the newcomers such as *Asperococcus bullosus, Ectocarpus luteolus, Nitophyllum uncinatum* and *Trailliella intricata* have a definite maximum occurrence on southern coasts. These species are therefore on the northern fringe of their area of distribution. Similarly, species such as *Stictyosiphon subarticulatus* and *S. tortilis* belong to higher latitudes and have moved southwards. The Isle of Man therefore is a meeting ground for migrants from both northern and southern floras. The greatest influx of

newcomers has been from the south. This fact might indicate an amelioration of physical conditions during the past twenty years; but, unfortunately for the theory, it has been observed that about an equal number of species, also of more southerly distribution, seem to have disappeared from the flora during the same period. Comparison of the present records from the Port Erin Station with the lists of older collectors for Douglas Bay shows that about twenty species with definitely southern distribution are missing from the south-west corner of the Island. It is of course conceivable that they are inhabitants of the sub-littoral zone and inaccessible to the collector. The most careful search has been made of the collecting area and the conclusion reached that either the Douglas Bay records were of plants detached from their hold in deep water and cast up by the tide, or that the species have actually disappeared from the flora, for they are not now to be found despite assiduous search even in their original localities. The outstanding species under discussion are:

Cystoseira ericoides
C. discors
C. fibrosa
Phyllophora palmettoides
Gymnogongrus Griffithsiae
G. Norvegicus
Nitophyllum Gmelini
Dasya ocellata
Seirospora Griffithsiana
Compsothamnion thuyoides
Ceramium fastigiatum
C. circinnatum
Gloiosiphonia capillaris

Owing to some obscure factor of the environment these species have not retained their place in the flora of the Island, but in view of the fact that the general trend of immigration appears to be from the south, it is possible that they will reappear sooner or later when ocean currents

or the movements of birds, or some other agent of distribution, brings about a re-colonisation of the Manx coast.

When compared with other areas the algal flora of the Isle of Man is not strikingly rich. Despite its border-line position between northern and southern floras, the Island does not wholly share either flora since the plants of restricted distribution in both are missing. It is difficult to account for some of the absentees even on the view expressed above; for example, *Spyridia filamentosa* and *Bostrychia scorpioides*, though frequent in the Menai Straits, have not yet been recorded for the Island. Nor does the Island flora show the richness characteristic of the Irish coast about the same latitude. Compared with the list of algae published in the Clare Island Survey, the Isle of Man records can show only 343 species and varieties against the 424 (exclusive of blue-green) of the Irish coast. The major portion of the algal flora therefore consists of species which it shares in common with the rest of the British Isles.

In compiling the systematic list an endeavour has been made to indicate, for the benefit of the student, where an illustration of each species may be found, by reference to literature which the student will be able to consult in the library of the Biological Station. Most of the references are to the "Phycologia Britannica," which is indicated in the text merely as "Harvey." The numerals in the reference refer to the volume and to the synoptic number of the species. It is frankly admitted that many of the illustrations referred to are not fully adequate; an attempt has been made to supply deficiencies by the inclusion of original drawings, but the expense involved in providing satisfactory illustration for all the species is prohibitive for this publication.

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CHLOROPHYCEAE

Sub-Order. PROTOCOCCINAE.
Fam. *CHARACIACEAE.*
Gen. **Codiolum,** A.Br.

C. gregarium, A. Br. Rare.
Fig.: Plate XV, 48, 53.
District: Port Erin.
Zone: H.W.O.S.T.
Occurrence: Casual, Annual, Summer.
Reproduction: July and August.

C. Petrocelidis, Kuck. Rare.
Fig.: Kuckuck (1894-6), Vol. I, p. 259.
District: Port Erin.
Zone: M.T. to H.W.O.N.T.
Occurrence: Casual, Annual, Summer.
Reproduction: Summer.
Notes: Found in *Petrocelis cruenta.*

Sub-Order. CONFERVOIDEAE.
Fam. *BLASTOSPOREAE.*
Gen. **Prasiola,** Ag.

P. stipitata, Suhr. Locally abundant (see note 1, p. 105).
Fig.: Plate XVI, 59.
District: Port Erin; Peel; The Chasms; Port St. Mary.
Zone: H.W.O.S.T.
Occurrence: Pseudo-perennial.
Reproduction: Common throughout year.
Notes: Found under rocks inhabited by sea-birds.

Fam. *ULVACEAE.*
Gen. **Pringsheimia,** Rke.

P. scutata, Rke. Not uncommon.
Fig.: Oltmanns I, p. 301.
District: Port Erin; Port St. Mary; Fleshwick; Castletown.
Zone: No definite zone.
Occurrence: Sporadic, same as host.
Reproduction: All times.
Notes: Epiphytic on many algae, e.g.: *Polysiphonia, Ceramium,* etc.

Gen. **Monostroma,** Thur.

a Eumonostroma

M. Wittrockii, Born.

Fig. : Hauck, Meeresalgen, p. 423.
District : Port Erin ; Port St. Mary ; Pooyllvaaish.
Zone : M.T. zone in pools.
Occurrence : Annual, Spring and Summer.
Reproduction : Spring and Summer.

b Ulvaria

M. Grevillei, Wittr. Common.

Fig. : Harvey IV, 341 (as *Ulva lactuca* Linn.]
District : Common in all districts.
Zone : M.T. pools to H.W.O.N.T.
Occurrence : Annual, Spring and Summer.
Reproduction : Most marked in August.

M. Grevillei, Wittr., var. *Cornucopiae*, Batt. Uncommon.

Fig. : Harvey IV, 330 [as *Enteromorpha cornucopiae*]
District : Port Erin ; Port St. Mary.
Zone : M.T. pools.
Occurrence : Spring and Summer.
Reproduction : Spring and Summer.
Notes : Generally epiphytic on *Corallina officinalis*. This appears to be the young stage of *Monostroma Grevillei*.

Gen. **Capsosiphon,** Gobi.

C. aureolus, Gobi.

Fig. : Hauck, Meeresalgen, p. 434 [as *Enteromorpha aureola* (Ag.) Kütz.]
District : Port Erin ; Chasms.
Zone : H.W.O.S.T.
Occurrence : Casual.
Reproduction : Frequent.
Notes : Mixed with *Prasiola stipitata* and *Enteromorpha micrococca* on the concrete at the end of Port Erin Promenade, just above the broken breakwater.

Gen. **Percursaria,** Bory.

P. percursa, Rosenv. Uncommon.

Fig. : Plate XV, 55, 56.
District : Port Erin ; Port St. Mary ; Peel.
Zone : M.T. to H.W.O.N.T.
Occurrence : Pseudo-perennial.
Reproduction : At all times of year.
Notes : Found occasionally in quiet pools on the shore in the summer, but frequent in lobster tanks at Biological Station during winter.

Gen. **Enteromorpha,** Link.

E. clathrata, J. Ag. *a genuina,* Batt. Common.
Fig.: Harvey IV, 335.
District: Port Erin; Port St. Mary; Castletown; Peel.
Zone: H.W.O.N.T. in Summer; M.T. zone in Winter.
Occurrence: Pseudo-perennial; maximum development in Summer.
Reproduction: At all times of the year.

E. paradoxa, Kütz, var. *typica,* Batt.
Fig.: Harvey IV, 334 [as *Enteromorpha erecta*].
Notes: Recorded by R. J. Harvey-Gibson. No data available.

E. Ralfsii, Harv. Occasional.
Fig.: Harvey IV, 339.
District: Port Erin; Port St. Mary.
Zone: M.T. zone.
Occurrence: Summer, Annual.
Reproduction: Summer.

E. torta, Reinb. Frequent.
Fig.: Harvey IV, 338 [as *Enteromorpha percursa*].
District: Port Erin; Port St. Mary.
Zone: M.T. zone to L.W.O.N.T.
Occurrence: Summer, Annual.
Reproduction: Summer.

E. ramulosa, Hook, var. *robusta,* Hauck. Locally abundant.
Fig.: Harvey IV, 336.
District: Port Erin; Port St. Mary.
Zone: M.T. zone to L.W.O.N.T.
Occurrence: Annual, Spring and Summer.
Reproduction: Summer.
Notes: Most frequent in pools on gently sloping shores.

E. compressa, Grev. Common.
Fig.: Harvey IV, 332.
District: Common everywhere.
Zone: H.W.O.S.T. to M.T. zone.
Occurrence: Pseudo-perennial; but maximum development in early summer.
Reproduction: At all times of the year. Copious in August; surface of pools green with escaping zoids.
Notes: Most luxuriant where fresh water streams present.

E. Linza, J. Ag., var. *lanceolata* (Kütz). Frequent.
Fig.: Harvey IV, 342.
District: Port Erin; Port St. Mary; Castletown.
Zone: All zones.
Occurrence: Pseudo-perennial.
Reproduction: Summer.
Notes: Frequent in Port Erin Bay in July where fresh water flows down the sand at north end of Bay; also frequent in deep pools on Port St. Mary shore in April, May, and June.

E. intestinalis, Link. Locally abundant.

Fig. : Harvey IV, 331.
District : Port Erin ; Port St. Mary ; Castletown ; Pooyllvaaish.
Zone : H.W.O.S.T.
Occurrence : Pseudo-perennial.
Reproduction : At all times, maximum in Summer.
Notes : Found in high brackish pools at Pooyllvaaish and Port St. Mary. Very large specimens obtained from estuary of river at Castletown.

E. micrococca, Kütz, var. *tortuosa*, J. Ag. Locally abundant.

Fig. : Plate XV, 49, 50, 52.
District : Port Erin ; The Chasms.
Zone : H.W.O.S.T.
Occurrence : Pseudo-perennial.
Reproduction : At all times of the year.
Notes : Found mixed with *Prasiola stipitata*.

Gen. **Ulva**, L.

U. lactuca, L. var. *latissima*, D.C. Abundant.

Fig. : Harvey IV, 340 [as *U. latissima*].
District : Abundant everywhere.
Zone : Occurs in all zones.
Occurrence : Pseudo-perennial, maximum development in Summer.
Reproduction : At all times of the year, maximum sporing in July and August.
Notes : Very abundant on Port Erin shore, where fresh water present. Diminishes in September, leaving shore white with depleted plants. More common in M.T. zone in winter, but migrates to upper zone in Summer.

Fam. *ULOTHRICHACEAE*.

Gen. **Ulothrix**, Kütz.

U. implexa, Kütz.

Fig. : Harvey IV, 370 [as *Lyngbya Cutleriae*].
District : Port Erin.
Occurrence : Sporadic.
Reproduction : Usually reproductive whenever found.
Notes : Found on the sides of the fish tanks at Biological Station.

U. flacca, Thur. Not uncommon.

Fig. : Harvey IV, 369 [as *Lyngbya flacca*].
District : Port Erin ; Port St. Mary ; Castletown ; Pooyllvaaish.
Zone : L.W.O.N.T.
Occurrence : Annual, Summer.
Reproduction : Summer.
Notes : Generally found in brackish pools near high water zone.

Fam. *CHAETOPHORACEAE.*

Gen. **Blastophysa,** Rke.

B. rhizopus, Rke. Occasional.
Fig.: Oltmanns I, p. 264.
District: Port Erin; Port St. Mary.
Zone: All zones.
Occurrence: Sporadic.
Reproduction: At all times of the year.
Notes: Parasitic in *Ulva lactuca.*

Gen. **Endoderma,** Lagerh.

E. viride Lagerh. Frequent.
Fig.: Hauck, p. 463 [as *Entocladia viridis*].
District: Port Erin; Port St. Mary.
Zone: All zones according to host.
Occurrence: Sporadic.
Reproduction: Whenever found.
Notes: Found as endophyte in the walls of many Rhodophyceae, e.g. *Ceramium rubrum.*

E. Wittrockii, Wille. Frequent.
Fig.: Hauck, p. 463 [as *Entocladia Wittrockii*].
District: Port Erin; Port St. Mary.
Zone: All zones according to host.
Occurrence: Sporadic.
Reproduction: At all times of the year.
Notes: Found as endophyte in many *Phæophyceae.*

E. flustrae, Batt. Rare.
Fig.: Plate XV, 54.
District: Port Erin.
Occurrence: Casual, Summer.
Notes: Found in *Flustra* species; dredged or cast ashore.

E. flustrae, Batt, var. *Phillipsii,* Batt. Occasional.
Fig.: Plate XV, 51.
District: Port Erin.
Zone: L.W.O.N.T.
Occurrence: Sporadic.
Reproduction: April, possibly at other times too.
Notes: Parasitic in *Alcyonidium hirsutum,* attached to species of Delesseria.

Fam. *CLADOPHORACEAE.*

Gen. **Urospora,** Aresch.

U. isogona, Batt. Common (= *U. mirabilis Aresch,* as quoted by Cotton in Clare Island Survey).
Fig.: Plate XIV, 42, 47.
District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.
Zone: H.W.O.S.T. to M.T. zone.
Occurrence: Pseudo-perennial.

Reproduction : Zoospores and gametes together in Autumn but zoospores precede gametes in Spring.

Notes : Always occurs higher up the shore than *U. bangioides* and attains maximum growth during Winter and Spring months.

U. bangioides, Holm and Batt. Locally frequent.

Fig. : Plate XVI, 46.

District : Port Erin.

Zone : L.W.O.N.T. to L.W.O.S.T.

Occurrence : Pseudo-perennial.

Reproduction : Asexual reproduction by zoospores in Winter, sexual reproduction in Spring.

Notes : Only been found at low water covering large stretches of rock ; is not able to stand long exposures to the air.

U. collabens, Holm and Batt. Rare.

Fig. : Plate XIV, 41.

District : Port St. Mary.

Zone : H.W.O.N.T.

Occurrence : No data.

Reproduction : No data.

Notes : Found mixed with *Urospora isogona*.

Gen. **Chaetomorpha,** Kütz.

Occurring separately or together as components of flora in top pools. Frequently in pools that are inhabited exclusively by *Chlorophyceae*, that is, pools in which the hydrogen ion concentration rises high during Summer.

C. tortuosa, Kütz. Frequent.

Fig. : Harvey IV, 321 [as *Conferva tortuosa*].

District : Port Erin ; Port St. Mary ; Castletown ; Pooyllvaaish ; Douglas Bay.

Zone : H.W.O.N.T.

Occurrence : Pseudo-perennial.

Reproduction : No data.

Notes : Forms tangled skeins loosely tangled round other algae, e.g., Corallina. May become conspicuous in early summer at Port St. Mary.

C. litorea, Cook. Not common.

Fig. : Harvey IV, 318 [as *Conferva litorea*].

District : Port Erin ; Douglas Bay (Talbot).

Zone : L.W.O.N.T.

Occurrence : No data. Single record for February.

Reproduction : No data.

Notes : Few threads only have been found. These were entangled in *Sphacelaria cirrhosa*. Cotton regards this species as a slender form of *Chaetomorpha linum*. Since our specimen had the occasional swollen cells characteristic of *C. litorea* as illustrated in Harvey, we have retained it under this name.

C. linum, Kütz. Frequent.

Fig.: Harvey IV, 320 [as *Conferva sutoria* Berk.]
District: Port Erin; Port St. Mary.
Zone: H.W.O.S.T.
Occurrence: Summer, Annual.
Reproduction: No data.
Notes: Filaments deep green, tangled in masses generally in brackish pools at high-water mark.

C. aerea, Kütz. Frequent.

Fig.: Harvey IV, 324 [as *Conferva aerea*].
District: Port Erin; Port St. Mary; Douglas Bay (Talbot).
Zone: H.W.O.N.T. to M.T. zone.
Occurrence: Pseudo-perennial.
Reproduction: At all times of the year.
Notes: Forms tangled ropes up to a foot long in pools on upper part of shore.

C. melagonium, Kütz. Frequent.

Fig.: Harvey IV, 323 [as *Conferva melagonium*].
District: Port Erin; Port St. Mary; Douglas Bay (Talbot); Clay Head (Brady).
Zone: H.W.O.N.T. to M.T. zone.
Occurrence: Pseudo-perennial.
Reproduction: At all times of the year; maximum in Spring.
Notes: Occurs as isolated threads in lower half of littoral zone in Winter, but develops in tufts in upper half in Summer.

C. crassa Kütz. Frequent.

Fig.: Harvey IV, 319 [as *Conferva linum* Roth.]
District: Castletown; Poollvaaish.
Zone: M.T.
Occurrence: Annual, Spring and Summer.
Reproduction: Whenever found.

Gen. **Rhizoclonium,** Kütz.

R. riparium, Harv. Frequent.

Fig.: Harvey IV, 314.
District: Port Erin; Port St. Mary.
Zone: H.W.O.N.T.
Occurrence: Pseudo-perennial. Maximum development in Spring and Summer.
Reproduction: At all times of the year.
Notes: Distinguished by fine hook-like branches.

R. Kerneri, var. *endozoica* Wille.

Fig.: Plate XIX, 77.
District: Port Erin; Port St. Mary; Castletown.
Zone: Wherever host may be found.
Occurrence: Sporadic.
Notes: In the tissues of *Halichondria panicea*.

Gen. **Cladophora,** Kütz.

C. pellucida, Kütz. Frequent

Fig. : Harvey IV, 291.
District : Frequent in all districts.
Zone : M.T. to L.W.O.N.T.
Occurrence : Pseudo-perennial.
Reproduction : Spring onwards.
Notes : Often find *Schmitziella endophloea* as parasite in the *C. pellucida.* Usually inhabits deep pools in lower half of littoral zone. Frequent in Summer, but reduced to basal parts of plant in Winter.

C. Hutchinsiae, Harv. Frequent.

Fig. : Harvey IV, 294.
District : Port St. Mary ; Castletown ; Pooyllvaaish ; Douglas Bay (Gatty).
Zone : L.W.O.N.T.
Occurrence : Pseudo-perennial.
Reproduction : July to September.
Notes : One of the most distinguished and luxuriant of *Cladophora* spp. Reduced to basal parts in Winter.

C. rupestris, Kütz. Abundant.

Fig. : Harvey IV, 297.
District : Common everywhere.
Zone : M.T. zone to L.W.O.N.T.
Occurrence : Pseudo-perennial.
Reproduction : Common during Spring and Summer. Maximum in March.
Notes : In Spring and Summer forms an almost continuous carpet in middle and lower littoral zone ; can be found as relics on limpet shells or on rock surfaces amongst other algae in Winter. Numerous sporelings recognisable in January.

C. rupestris, Kütz, var. *nuda,* Holm and Batt.

Fig. : Harvey IV, 296 [as *C. nuda*].
District : Port Erin ; Port St. Mary.
No other data available. Recorded by R. J. Harvey-Gibson.

C. utriculosa, Kütz. Frequent.

Fig. : Harvey IV, 298 [as *C. lætevirens*].
District : In all districts.
Zone : M.T. zone to L.W.O.N.T.
Occurrence : Annual.
Reproduction : Spring and Summer.
Notes : Common component of pool flora in spring and summer in middle third of littoral zone on gently sloping shores, extending downwards to low water. Plants conspicuous, bright green, three to four inches long.

C. gracilis, Kütz. Uncommon.
Fig.: Harvey IV, 300.
District: Port Erin; Port St. Mary; Douglas Bay (Talbot).
Zone: L.W.O.S.T.
Occurrence: Annual.
Reproduction: No data.
Notes: Deep water form only obtained at low water of spring tides in summer.

C. flexuosa, Harv. Rare.
Fig.: Harvey IV, 299.
District: Port Erin.
Zone: L.W.O.S.T.
Occurrence: Annual, Summer.
Reproduction: Summer.
Notes: Generally occurs in deep pools at low water and below.

C. albida, Kütz. Not uncommon.
Fig.: Harvey IV, 304.
District: Port St. Mary; Douglas Bay (Mrs. Gatty).
Zone: M.T. zone and below.
Occurrence: Annual, Summer.
Reproduction: Summer.
Notes: Occurs on rocks and in pools.

C. albida, Kütz, var. *refracta*, Thur. Not common.
Fig.: Harvey IV, 303 [as *C. refracta*].
District: Port Erin; Douglas Bay (Brady).
Zone: L.W.O.S.T.
Occurrence: Annual, Summer.
Reproduction: No data.
Notes: In pools and on rocks at low water of Spring tides.

C. fracta, Kütz, var. *marina*, Hauck.
Fig.: Harvey IV, 313.
District: Port Erin.
No other data available. Recorded by R. J. Harvey-Gibson.

C. fracta, Kütz, var. *flavescens*, Batt. Not common.
Fig.: Harvey IV, 312 [as *C. flavescens*].
District: Port Erin; Pooyllvaaish.
Zone: H.W.O.N.T.
Occurrence: Pseudo-perennial.
Reproduction: Frequent all the year, maximum in Spring.
Notes: In stagnant pools in upper third of littoral zone.

C. arcta, Kütz. Frequent, common locally.
Fig.: Harvey IV, 307.
District: Port Erin; Port St. Mary; Castletown; Douglas Bay (Talbot).
Zone: All zones.
Occurrence: Perennial.
Reproduction: Spores March to September.
Notes: Forms an almost complete carpet near low water mark on the limestone ledges at Castletown; also occurs in pools in all zones up to high water mark.

C. uncialis, Kütz.

Fig.: Harvey IV, 306.
District: Douglas Bay.
Recorded by Talbot in his list as *C. lanosa*, var. *uncialis*, Thur.

C. lanosa, Kütz. Frequent.

Fig : Harvey IV, 305
District: In all districts
Zone: M.T. zone to L.W.O.N.T.
Occurrence: Summer, Annual.
Reproduction: Summer.
Notes: Same habitat as *C. utriculosa*. Epiphytic: forms delicate, almost spherical tufts three-quarters to one and a half inches in diameter on such algae as *Furcellaria*.

Fam. *GOMONTIACEAE.*

Gen. **Gomontia,** Born. et Flah.

G. polyrhiza, Born. et Flah.

Fig.: Oltmanns III, p. 474.
District: Port St. Mary.
Notes: Only a single record on whelk shell.

G. manxiana, Chodat.

No data. Recorded in Batter's list.
District: Castletown.

Fam. *BRYOPSIDACEAE.*

Gen. **Bryopsis,** Lamour.

B. hypnoides, Lamour. Not common.

Fig.: Harvey IV, 285.
District: Port Erin; Port St. Mary; Douglas Bay (Talbot).
Zone: M.T. zone downwards.
Occurrence: Pseudo-perennial.
Reproduction: June.
Notes: Generally found in deep sheltered pools in lower third of littoral zone; most frequent in Spring.

B. plumosa, Ag. Frequent.

Fig.: Harvey IV, 284.
District: In all districs.
Zone: M.T. zone.
Occurrence: Perennial.
Reproduction: In June and July.
Notes: Most plentiful in March to July in pools in the mid-tide zone. Commonly found under overhanging ledges in pools. Small and scattered plants can be found in deep pools in Winter.

Fam. *VAUCHERIACEAE.*
Gen. **Vaucheria,** D.C.

V. Thuretii, Woron.
Fig.: Harvey IV, 288 [as *Vaucheria velutina*].
District: Port Erin; Port St. Mary.
Zone: M.T. zone.
Notes: Scraped from the surface of limpets. No other data available.

Fam. *SPONGODIACEAE.*
Gen. **Codium,** Stackh.

C. adhaerens, Ag. Very rare.
Fig.: Harvey IV, 281.
District: Port St. Mary.
Zone: M.T. zone.
Occurrence: Perennial.
Reproduction: No data.
Notes: Found in one locality only; patch about 2 ft. square in area.

C. amphibium, Moore. Very rare.
Fig.: Harvey IV, 282.
District: Perwick Bay; Port St. Mary.
Notes: Has not been observed by authors; recorded in Batters' list.

C. tomentosum, Stackh. Frequent.
Fig.: Harvey IV, 283.
District: In all districts.
Zone: M.T. zone to L.W.O.N.T.
Occurrence: Perennial.
Reproduction: Winter and early Spring.
Notes: *C. tomentosum* generally occurs in deep pools, reaching maximum size in the Winter.

C. mucronatum, var. *atlanticum,* Cott. Frequent.
Fig.: Cotton, 1912.
District: Port Erin; Port St. Mary.
Zone: M.T. zone.
Occurrence: Pseudo-perennial or perennial.
Reproduction: Summer.
Notes: In pools.

PHAEOPHYCEAE.

Sub-Order. PHAEOSPOREAE.
Fam. *DESMARESTIACEAE.*
Gen. **Desmarestia,** Lamour.

D. viridis, Lamour. Frequent.
Fig.: Harvey I, 19.
District: In all districts.
Zone: L.W.O.S.T. in deep pools.
Occurrence: Annual.
Reproduction: Summer.

D. aculeata, Lamour. Common.

Fig.: Harvey I, 18.
District: In all districts.
Zone: Below L.W.O.S.T.
Occurrence: Perennial.
Reproduction: No data.
Notes: This species only obtained by dredging. Abundant September to November. Winter form maintained until March.

D. ligulata, Lamour. Rare.

Fig.: Harvey I, 17.
District: Port Erin; Port St. Mary; Castletown; Peel.
Zone: L.W.O.N.T. and below.
Occurrence: Annual, Spring and Summer.
Reproduction: No data.
Notes: Appears to be a deep water form, but young plants, 2 ins. long, were found at L.W.O.N.T. mark in February on the Port St. Mary ledges. Old plants frequently cast up in the Summer.

Fam. *DICTYOSIPHONACEAE.*
Gen. **Dictyosiphon,** Grev.

D. foeniculaceus, Grev. Common.

Fig.: Harvey I, 41.
District: In all districts.
Zone: H.W.O.N.T. to M.T. zone.
Occurrence: Annual, Summer.
Reproduction: Unilocular sporangia, Summer.
Notes: Very common on gently sloping shores such as Castletown, nearly filling the pools at mid-tide zone. In July forms a conspicuous band round the foot of the rocks on the northern end of Port Erin beach. In September and October nearly always epiphytic on *Chordaria flagelliformis.*

Fam. *PUNCTARIACEAE.*
Gen. **Mikrosyphar,** Kuck.

M. Polysiphoniae, Kuck. (See Note 2, p. 105.)

Fig.: Oltmanns III, p. 463.
District: Port St. Mary.
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: Plurilocular sporangia in February.
Notes: Endophytic in walls of *Polysiphonia urceolata;* has also been observed in *Ceramium Deslongschampsii* and *Callithamnion arbuscula.*

Gen. **Litosiphon,** Harv.

L. pusillus, Harv. Frequent.
Fig.: Harvey I, 49.
District: Port Erin; Port St. Mary; Douglas Bay (Talbot).
Zone: Same habitat as *Chorda filum.*
Occurrence: Annual, Summer.
Reproduction: Unilocular and plurilocular sporangia in July.
Notes: Generally found growing on *Chorda filum.*

L. Laminariae, Harv. Frequent.
Fig.: Harvey I, 50.
District: Port Erin; Port St. Mary; Castletown.
Zone: L W.O.N.T. to L.W.O.S.T.
Occurrence: Annual, Summer.
Reproduction: Plurilocular sporangia in June.
Notes: Found on the thalli of *Alaria,* etc., in Summer.

L. filiformis, Batt. Frequent.
Fig.: Oltmanns II, fig. 345 [as *Pogotrichum filiforme*].
District: Port Erin; Port St. Mary.
Zone: L.W.O.N.T. to L.W.O.S.T.
Occurrence: Annual, Spring and Summer.
Reproduction: Plurilocular sporangia in March.
Notes: Generally found epiphytic on the fronds of *Laminaria digitata.*

Gen. **Phloeospora,** Aresch. emend. Rke.

P. brachiata, Born. Frequent.
Fig.: Kuckuck (1929), p. 83.
District: Port Erin; Port St. Mary.
Zone: L.W.O.N.T.
Occurrence: Annual, Summer.
Reproduction: Unilocular sporangia in May and June. Plurilocular sporangia or both types in July, August, and September.
Notes: Frequent in certain localities. Generally found on *Rhodymenia palmata.* It disappears in September with most of the *Rhodymenia,* reappearing in May. Winter form unknown.

Gen. **Stictyosiphon,** Kütz.

S. subarticulatus, Hauck. Occasional.
Fig.: None available.
District: Port Erin; Port St. Mary.
Zone: M.T. zone to L.W.O.N.T. in pools.
Occurrence: Annual, Summer.
Reproduction: No data.

S. tortilis, Rke. Locally frequent.
Fig.: Plate XIII, 38.
District: Pooyllvaaish.
Zone: M.T. zone.
Occurrence: Annual, Spring and Summer.
Reproduction: Unilocular sporangia in April and May.
Notes: Common on the sandy shore at Pooyllvaaish; grows in patches.

Gen. **Striaria,** Grev.

S. attenuata, Grev.

Fig. : Harvey I, 42.

District : Port Erin.

Notes : Single record. Cast up in Summer bearing unilocular sporangia.

Gen. **Punctaria,** Grev.

P. plantaginea, Grev. Frequent.

Fig. : Harvey I, 44.

District : Port Erin ; Port St. Mary ; Castletown.

Zone : M.T. zone to L.W.O.N.T. in pools.

Occurrence : Pseudo-perennial, maximum in Spring.

Reproduction : Unilocular and plurilocular sporangia from April to July.

Notes : First appears as small plants on the limpets in January ; attains maximum size in early Summer, disappearing in August.

P. latifolia, Grev., var. *genuina,* Batt. Not common.

Fig. : Harvey I, 43.

District : Port Erin ; Port St. Mary ; Castletown ; Douglas Bay (Talbot).

Zone : H.W.O.N.T. to M.T. zone.

Occurrence : Annual, Summer.

Reproduction : Unilocular and plurilocular sporangia in Spring.

Notes : Generally occurs in shallow pools on gently sloping shores and on protected ledges.

P. tenuissima, Grev. Not common.

Fig. : Harvey I, 45.

District : Port Erin ; Port St. Mary ; Douglas Bay (Brady).

Zone : M.T. zone and below.

Occurrence : Summer, Annual.

Reproduction : Summer ; unilocular sporangia appearing at the end of May.

Notes : Generally found epiphytic on *Chorda filum.*

Fam. *SCYTOSIPHONACEAE.*

Gen. **Phyllitis,** Kütz.

P. zosterifolia, Rke. Rare.

Fig. : None available.

District : Port Erin ; Port St. Mary ; Perwick Bay.

Notes : Recorded by R. J. Harvey-Gibson. No data available.

P. fascia, Kütz, var. *genuina,* Batt. Frequent.

Fig. : Harvey I, 29 [as *Laminaria fascia*].

District : Port Erin ; Port St. Mary ; Castletown ; Douglas Bay (Talbot).

Zone : M.T. zone.

Occurrence : Pseudo-perennial, maximum occurrence in Winter.

Reproduction : Plurilocular sporangia January to March.

Notes : Appears in the mid-tide pools early in November ; disappears beginning of April ; probably migrates to deeper water during Spring and Summer. Common in certain localities.

Gen. **Scytosiphon**, Ag.

S. lomentarius, J.Ag. Common.

Fig.: Harvey I, 31 [as *Chorda lomentaria*].
District: In all districts.
Zone: H.W.O.N.T. to M.T. zone.
Occurrence: Pseudo-perennial.
Reproduction: Plurilocular sporangia from November to March.
Notes: See page 33.

S. lomentarius, J.Ag., var. *zostericola,* Thur. Not common.

Fig.: None available.
District: Port St. Mary; Castletown; Derby Haven.
Zone: L.W.O.S.T.
Notes: Found on the leaves of *Zostera.*

Fam. *HYDROCLATHRACEAE.*

Gen. **Colpomenia,** Derb. et Sol.

C. sinuosa, Derb. et Sol. Common.

Fig.: Oltmanns II, p. 64.
District: In all districts.
Zone: H.W.O.N.T. to L.W.O.N.T.
Occurrence: Pseudo-perennial.
Reproduction: Plurilocular sporangia in Summer; unilocular sporangia unknown.

Fam. *ASPEROCOCCACEAE.*

Gen. **Asperococcus,** Lamour.

A. fistulosus, Hooker (see Note 3, p. 105). Common.

Fig.: Harvey I, 48 [as *A. echinatus*].
District: In all districts.
Zone: H.W.O.N.T. to M.T. zone.
Occurrence: Pseudo-perennial.
Reproduction: In Autumn, unilocular and plurilocular sporangia on the same plants; in Winter unilocular sporangia numerous; in Spring unilocular and plurilocular sporangia on separate plants.
Notes: In Winter small specimens of *A. fistulusos* may be found in the high tide zone, but during the Summer they are present only in the M.T. zone.

A. bullosus, Lamour. Frequent.

Fig.: Harvey I, 47 [as *A. Turneri*].
District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.
Zone: M.T. zone to L.W.O.S.T.
Occurrence: Annual, Summer.
Reproduction: Unilocular sporangia in Summer.

A. compressus, Griff.

Fig.: Harvey I, 46.
Notes: Single record. Cast ashore at Pooyllvaaish. No other data available.

Gen. **Streblonema**, Derb. et Sol.

S. fasciculatum, Thur. Not uncommon.

Fig.: Hauck, p. 323.
District: Port Erin; Port St. Mary; Castletown.
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: Plurilocular sporangia in July and August.
Notes: Immersed amongst the cortical filaments of *Castagnea viresecns*. Disappears in Winter because the *Castagnea* is absent; may be present in Winter as an epiphyte elsewhere but has not yet been located.

S. infestians, Batt. Rare.

Fig.: Plate XIX, 78.
District: Port Erin.
Zone: Same as host, generally near low water mark.
Occurrence: Sporadic.
Reproduction: Plurilocular sporangia in April.
Notes: Endozoic in *Alcyonidium hirsutum*, on *Delesseria* species.

S. Zanardinii, Batt. Rare.

Fig.: Plate XII, 28, 32.
District: Port St. Mary; Castletown.
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: Plurilocular sporangia in April and May.
Notes: Found immersed in the cortical layer of *Chylocladia kaliformis*.

Gen. **Ectocarpus**, Lyngb.

E. parasiticus, Sauv. Very rare.

Fig.: Oltmanns III, p. 469. Plate XIII, 33, 37.
District: Port Erin.
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: Plurilocular sporangia in March.
Notes: Parasitic in the thallus of *Cystoclonium purpureum*.

E. brevis, Sauv. Rare.

Fig.: Plate XIX, 79.
District: Port Erin.
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: Plurilocular sporangia in Summer.
Notes: Parasitic in the thallus of *Ascophyllum nodosum*.

E. luteolus, Sauv. Not uncommon.

Fig.: Plate XI, 19, 20, 24.
District: Port Erin.
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: Plurilocular sporangia in July.
Notes: Parasitic in the thallus of *Fucus vesciculosus*.

E. microscopicus, Batt. Rare.

Fig.: Oltmanns II, p. 25 [as *Cylindrocarpus microscopicus*].
District: Port Erin.
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: Plurilocular sporangia in April.
Notes: Parasitic in *Plumaria elegans*.

E. tomentosoides, Farlow. Common.

Fig.: Plate VIII, 1.
District: Port Erin; Port St. Mary.
Zone: Same as host.
Occurrence: Perennial or Pseudo-perennial.
Reproduction: Plurilocular sporangia at all seasons.
Notes: Epiphytic on *Laminaria saccharina*. Common at all seasons of the year.

E. velutinus, Kütz. Not uncommon.

Fig.: Plate X, 15.
District: Port St. Mary; Castletown.
Zone: Same as host.
Occurrence: Pseudo-perennial.
Reproduction: Unilocular sporangia abundant in late Summer; plurilocular sporangia rare, found only in late September.
Notes: Found growing on the receptacles of *Himanthalia lorea* on the sides of deep pools and on overhanging ledges in the sub-littoral zone. Appears on the young *Himanthalia* in Summer, reaches maximum in September, then diminishes until in April it is difficult to find.

E. simplex, Crn. Rare.

Fig.: Plate IX, 8, 9, 11, 12.
District: Port St. Mary.
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: Unilocular and plurilocular sporangia in March.
Notes: On *Codium tomentosum*.

E. terminalis, Kütz. Rare.

Fig.: Plate X, 14.
District: Port Erin, Port St. Mary.
Zone: M.T. zone.
Occurrence: Sporadic.
Reproduction: Unilocular and plurilocular sporangia in Winter.
Notes: Scraped from the surface of limpet shells.

E. confervoides, Le Jol. Common.

Fig.: Plate VIII, 3, 4.
District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.
Zone: M.T. zone and below.
Occurrence: Annual, Spring, and Summer.
Reproduction; Unilocular sporangia rare, developed spring and Autumn; plurilocular sporangia common in Summer.
Notes: Common, sometimes abundant, on rock surfaces, also epiphytic on other algae.

E. siliculosus, Kütz. Common.

Fig.: Harvey I, 80. Knight (1929).
District: In all districts.
Zone: M.T. zone downwards.
Occurrence: Pseudo-perennial.
Reproduction: Plants in Spring and Autumn bear unilocular sporangia. Plurilocular sporangia general from March to August.
Notes: Common on littoral zone in Spring and Summer in sheltered situations; reduced in Winter to filamentous creeping or adherent plantlets reproducing by plurilocular sporangia.

E. fasciculatus, Harv., var. *typica*. Frequent.

Fig.: Harvey I, 83. Plate XI, 23, 25.
District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.
Zone: L.W.O.N.T. to L.W.O.S.T.
Occurrence: Pseudo-perennial.
Reproduction: Unilocular and plurilocular sporangia on same plant. March to August.
Notes: Usually occurs as an epiphyte on *Laminaria* and *Himanthalia* fronds. Spring is the period of most luxuriant growth, but can be found in Winter as battered relics on the *Laminaria* fronds. In Summer the plants are covered with diatoms.

E. fasciculatus, Harv. var. *draparnaldioides*, Crn. Rare.

Fig.: Plate XIX, 80.
District: Port St. Mary.
Zone: L.W.O.N.T. to L.W.O.S.T.
Occurrence: Pseudo-perennial.
Reproduction: Unilocular and plurilocular sporangia in Spring and Summer.
Notes: Generally found mixed with *E. fasciculatus*, var. *typica*.

E. fasciculatus, Harv. var. *refracta* Ardissone.

Fig.: Plate VIII, 5, 6.
District: Port St. Mary.
Zone: L.W.O.N.T. to L.W.O.S.T.
Occurrence: Pseudo-perennial.
Reproduction: Unilocular sporangia from Feb. to April, plurilocular sporangia from March to June.

E. tomentosus, Lyngb. Abundant.

Fig.: Harvey I. 85.
District: In all districts.
Zone: Same as host.
Occurrence: Pseudo-perennial.
Reproduction: Unilocular sporangia in Spring and Autumn; plurilocular sporangia common all Summer.
Notes: Common everywhere in the summer, especially as an epiphyte on *Fucus vesiculosus* and *Fucus serratus*. Minute creeping filaments bearing plurilocular sporangia present in the Winter; in Spring these give rise to the typical upright plants.

E. ovatus, Kjellm. var. *arachnoideus*, Rke. Very rare.

Fig.: Plate XII, 30.

Reproduction: Unilocular and plurilocular sporangia in Winter.

Notes: Found in lobster tank at Marine Biological Station.

E. Hincksiae, Harv. Locally abundant.

Fig.: Harvey I, 84.

District: Port Erin.

Zone: Same as host.

Occurrence: Pseudo-perennial.

Reproduction: Plurilocular sporangia present all Summer; unilocular sporangia rare and formed only in Spring.

Notes: Epiphytic on *Laminaria* thalli, especially *Saccorhiza polyschides*. During winter basal parts only remain. Best growth in spring and early Summer. Has occasionally been found on species of *Fucus*.

E. granulosus, Ag. Not uncommon.

Fig.: Harvey I, 92.

District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.

Zone: L.W.O.S.T. and below.

Occurrence: Pseudo-perennial.

Reproduction: Plurilocular sporangia common in Summer (suspected to be of two types with unequal sized loculi). Unilocular sporangia occasional in Spring on same thallus as plurilocular sporangia.

Notes: Deep water form generally found in situations where there is plenty of water movement; frequently forms a fringe round the rim of the Breakwater buoy (Port Erin).

Gen. **Pylaiella**, Bory.

P. littoralis, Kjellm. Abundant.

Fig.: Knight (1923).

District: In all districts.

Zone: H.W.O.N.T. to L.W.O.N.T.

Occurrence: Pseudo-perennial.

Reproduction: Plurilocular sporangia normal to plants growing on *Ascophyllum nodosum*. Unilocular sporangia usual on plants growing on *Fucus* species. Both types of host may bear occasional plants with unilocular and plurilocular sporangia.

Notes: One of the commonest *Ectocarpaceae* found between tide marks. Most luxuriant in summer but persisting as somewhat truncated diatom-covered plants in winter.

Gen. **Isthmoplea,** Kjellm.

I. sphaerophora, Kjellm. Not common.

Fig. : Harvey I, 93 [as *Ectocarpus sphaerophorus*]. Plate IX, 18.
District : Port Erin ; Port St. Mary ; Castletown ; Pooyllvaaish.
Zone : Same as host.
Occurrence : Pseudo-perennial.
Reproduction : Unilocular sporangia in Spring and early Summer ; plurilocular sporangia in Summer.
Notes : Casual in sheltered places generally epiphytic on *Plumaria elegans* and *Cladophora rupestris*. Most readily recognisable by the unilocular sporangia but plants bearing plurilocular sporangia only may have been confused with other *Ectocarpaceae* and so have escaped record.

Gen. **Myriotrichia,** Harv.

M. clavaeformis, Harv. Frequent.

Fig. : Kuckuck (1899), p. 39.
District : In all districts.
Zone : Same as host.
Occurrence : Annual, Summer.
Reproduction : Unilocular and plurilocular sporangia on the same thallus ; plurilocular sporangia predominate at beginning of Summer, unilocular at the end.
Notes : First makes its appearance in May or June as an epiphyte on other *Phaeophyceae* (occasionally on *Enteromorpha*). Host plants are frequently Summer annuals, e.g. *Chordaria, Castagnea, Dictyosiphon*. Winter form unknown.

M. filiformis, Harv. Not common.

Fig. : Kuckuck (1899), p. 40. Plate XI, 21, 22.
District : Port Erin ; Castletown.
Zone : Same as host.
Occurrence : Summer annual.
Reproduction : See *Myriotrichia clavaeformis ;* same type of reproduction.
Notes : Generally found epiphytic on *Dictyosiphon foeniculaceus*.

Fam. *ARTHROCLADIACEÆ*.

Gen. **Arthrocladia,** Duby.

A. villosa. Duby. Rare.

Fig. : Harvey I, 20.
District : Fleshwick Bay.
Zone : Sub-littoral.
Occurrence : Summer.
Reproduction : Unilocular sporangia.
Notes : One record only, dredged.

Fam. *ELACHISTACEAE.*

Gen. **Myriactis,** Kütz.

M. pulvinata, Kütz. Not common.

Fig.: Kuckuck (1929), p. 39.
District: Pooyllvaaish.
Zone: L.W.O.N.T.
Occurrence: No data.
Reproduction: Unilocular and plurilocular sporangia in Summer.
Notes: Found growing on fronds of *Halidrys* in deep pools in the low tide zone.

M. stellulata, Batt. Not common.

Fig.: Harvey I, 62. [as *Elachista stellulata*].
District: Port Erin; Port St. Mary; Peel.
Zone: Same as host.
Occurrence: Summer annual.
Reproduction: Unilocular and plurilocular sporangia from end of June to the beginning of September.
Notes: Epiphytic on *Dictyota dichotoma.*

M. Haydeni, Batt.

Fig.: Kuckuck (1929) p. 38.
District: Port Erin.
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: No data.
Notes: An epiphyte growing on *Scytosiphon lomentarius* has been provisionally referred to this species. The plants were young—no sporangia were formed, hence precise identification was not possible.

Gen. **Elachista,** Duby.

E. fucicola, Fries. Common.

Fig.: Harvey I, 59.
District: In all districts.
Zone: Same as host.
Occurrence: Perennial or pseudo-perennial.
Reproduction: Unilocular sporangia at all times of the year; plurilocular sporangia unknown.
Notes: Common everywhere on *Fucus vesciculosus* and *Fucus serratus*; more plentiful in the Summer.

E. flaccida, Aresch. Not common.

Fig.: Harvey I, 60.
District: Port St. Mary.
Zone: Same as host.
Occurrence: Annual, Spring.
Reproduction: Unilocular sporangia in Summer.
Notes: Epiphytic on *Halidrys siliquosa.*

E. scutulata, Duby. Frequent.

Fig.: Harvey I, 63.
District: Port Erin; Port St. Mary; Douglas Bay (Talbot).
Zone: Same as host.
Occurence: Annual, Summer.
Reproduction: Unilocular sporangia in Summer.
Notes: Occurs epiphytically on the *Himanthalia* thongs in Spring, Summer and early Autumn.

Gen. **Leptonema,** Reinke.

L. fasciculatum, Rke, var. *majus*, Rke. Very rare. (See note 5, p. 110.)

Fig.: Plate XIII, 35, 36, 39.
District: Port Erin.
Zone: M.T. zone.
Occurrence: Sporadic.
Reproduction: Plurilocular sporangia in February and March. Unilocular sporangia developed in April.
Notes: Found growing epiphytically on *Cladostephus spongiosus* and on the byssi of *Mytilus*.

Fam. *SPHACELARIACEAE*.

Gen. **Sphacelaria,** Lyngb. (See note 6, p. 111).

S. radicans, Harv. Not common.

Fig.: Harvey I, 78.
District: Port Erin; Port St. Mary; Pooyllvaaish.
Zone: M.T. zone.
Occurrence: Perennial.
Reproduction: Unilocular sporangia in Spring; no record for plurilocular sporangia.

S. cirrhosa, Ag., var. *pennata*, Hauck. Frequent.

Fig.: Harvey I, 76.
District: Port Erin; Port St. Mary; Douglas Bay (Talbot); Peel.
Zone: M.T. zone and below in pools.
Occurrence: Perennial.
Reproduction: Unilocular sporangia in Winter. Frequently bears propagules.
Notes: This species may be found as an epiphyte on *Desmarestia aculeata*.

S. cirrhosa, Ag., var. *fusca*, Holm et Batt. Rare. (See note 7, p. 111.)

Fig.: Harvey I, 77 [as *S. fusca*].
District: Port Erin; Port St. Mary; Douglas Bay (Brady).
Zone: M.T. zone in pools.
Occurrence: Perennial.
Reproduction: Unilocular sporangia in winter. Frequently bears propagul es.

S. bipinnata, Sauv. Frequent. (See note 8, p. 112.)

Fig.: Clint, 1927.
District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.
Zone: L.W.O.S.T.
Occurrence: Perennial.
Reproduction: Unilocular and plurilocular sporangia developed in the Summer.
Notes: Found as an epiphyte on *Halidrys siliquosa* in deep pools at low water mark.

Gen. **Chaetopteris**, Kütz.

Ch. plumosa, Kütz. Occasional.

Fig.: Harvey I, 75 [as *Sphacelaria plumosa*].
District: Port Erin; Douglas Bay (Talbot); Peel.
Zone: L.W.O.N.T.
Occurrence: Perennial.
Reproduction: Unilocular sporangia in Spring.
Notes: Occasional in deep pools at low water mark or sometimes cast up.

Gen. **Cladostephus**, Ag.

C. spongiosus, Ag. Frequent.

Fig.: Harvey I, 71.
District: In all districts.
Zone: M.T. zone and below.
Occurrence: Perennial.
Reproduction: Unilocular and plurilocular sporangia on separate individuals in Winter.
Notes: Generally found on sand or mud-covered rocks.

C. verticillatus, Ag. Frequent.

Fig.: Harvey I, 70.
District: Port Erin; Port St. Mary; Douglas Bay (Talbot); Peel; Pooyllvaaish.
Zone: M.T. zone and below.
Occurrence: Perennial.
Reproduction: Unilocular and plurilocular sporangia in Winter.

Gen. **Halopteris**, Kütz.

H. filicina, Kütz. Very rare.

Fig.: Harvey I, 72 [as *Sphacelaria filicina*].
District: Port Erin; Port St. Mary.
Zone: L.W.O.S.T. and below.
Occurrence: Perennial.
Reproduction: Unilocular sporangia in Spring.

Halopteris filicina Kütz, var. *sertularia* (Bonnem.)
Fig.: Harvey I, 73 [as *Sphacelaria sertularia* Bonnem].
District: Fleshwick Bay.
Zone: Sub-littoral.
Occurrence: No data.
Reproduction: Unilocular sporangia in August.
Notes: Single record only, dredged.

Gen. **Stypocaulon,** Kütz.

S. scoparium, Kütz. Occasional.
Fig.: Harvey I, 74 [as *Sphacelaria scoparia*].
District: Port Erin; Castletown; Douglas Bay (Talbot).
Zone: L.W.O.S.T. and below.
Occurrence: Perennial or biennial.
Reproduction: Unilocular sporangia in Autumn.

Fam. *MYRIONEMACEAE.*

Gen. **Myrionema,** Grev.

M. strangulans, Grev., var. *typica,* Batt. Frequent.
Fig.: Harvey I, 66.
District: Port Erin; Port St. Mary; Castletown; Douglas Bay (Brady, Talbot).
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: Unilocular sporangia in Summer.
Notes: Frequent on *Enteromorpha* and *Ulva.*

M. strangulans, var. *punctiforme,* Holm et Batt.
Fig.: Harvey I, 68 [as *M. punctiforme*].
Note: Recorded by Talbot. No data available.

M. aecidioides, Sauv. Frequent.
Fig.: Oltmanns III, p. 469 [as *Phycocelis aecidioides*].
District: Port Erin.
Zone: Same as host.
Occurrence: Pseudo-perennial.
Reproduction: Plurilocular sporangia in Spring.
Notes: Occurs commonly on *Laminaria digitata.*

M. saxicola, Kuck. Rare.
Fig.: Kuckuck (1897), p. 390, figs. 13 and 14.
District: Port St. Mary.
Zone: M.T. zone.
Occurrence: No data.
Reproduction: Unilocular sporangia in Winter.

Gen. **Ulonema,** Foslie.

U. rhizophorum, Foslie. Occasional.
Fig.: Plate IX, 7, 10, 13.
District: Port Erin; Port St. Mary.
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: Unilocular sporangia in June.
Notes: Commonly on *Dumontia incrassata.*

Gen. **Hecatonema,** Sauv.

H. maculans, Sauv. Occasional.
Fig.: Plate X, 17.
District: Port Erin; Port St. Mary.
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: Plurilocular sporangia in early Autumn.
Notes: Usually found epiphytic on *Corallina officinalis.*

Gen. **Chilionema,** Sauv.

C. Nathaliae, Sauv.
Fig.: Harvey I, 67 [as *Myrionema Leclancherii*].
District: Douglas Bay; Peel.
Notes: Recorded by Harvey-Gibson and Brady. No data available.

Gen. **Ascocyclus,** Magn. (See note 9, p. 112.)

A. orbicularis, Magn. Not common.
Fig.: Børgesen (1926), *Phaeophyceae,* p. 63.
District: Port St. Mary; Douglas Bay (Talbot).
Notes: On the leaves of *Zostera.*

A. Saccharinae, Cotton. Not common.
Fig.: Cotton, 1912, Pl. X. Plate XII, 26, 31.
District: Port Erin.
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: Plurilocular sporangia in Winter.
Notes: Found on *Laminaria saccharina.*

Gen. **Ralfsia,** Berk.

R. verrucosa, Aresch. Frequent.
Fig.: Harvey I, 58 [as *R. deusta*].
District: Port Erin; Port St. Mary.
Zone: H.W.O.N.T.
Occurrence: Perennial.
Reproduction: Unilocular and plurilocular sporangia in Winter.
Notes: Often found covering limpet shells in any zone, but forming conspicuous confluent discs in rock pools near H.W.O.N.T.

Gen. **Lithoderma,** Aresch.

L. fatiscens, Aresch. Rare.
Fig.: Oltmanns II, p. 15.
District: Port St. Mary.
Zone: M.T. to L.W.O.N.T.
Occurrence: Sporadic.
Reproduction: Unilocular sporangia in February.
Notes: Scraped from the surface of limpet shells.

Fam. *CHORDARIACEAE.*

Gen. **Stilophora,** J.Ag.

S. rhizodes, J. Ag.

Fig.: Harvey I, 39.
District: Port Erin.
Note: Single specimen cast up in Summer bearing unilocular sporangia.

Gen. **Chordaria,** Ag.

C. divaricata, Ag. Very rare.

Fig.: Harvey I, 52.
District: Port Erin.
Reproduction: Unilocular sporangia in Summer.
Notes: Has only been found cast up on the shore in Summer.

C. flagelliformis, Ag. Frequent.

Fig.: Harvey I, 51.
District: Port Erin; Port St. Mary; Castletown; Douglas Bay (Talbot).
Zone: H.W.O.N.T. to M.T. zone.
Occurrence: Annual, Summer.
Reproduction: Unilocular sporangia in Summer and early Autumn.
Notes: Found in pools generally bearing *Dictyosiphon foeniculaceus* as an epiphyte. Appears beginning of July and disappears at the end of November.

Gen. **Mesogloia,** Ag.

M. vermiculata, Le Jol. Frequent. (See note 10, p. 113.)

Fig.: Harvey I, 53 [as *M. vermicularis*].
District: Port Erin; Douglas Bay (Brady, Talbot).
Zone: L.W.O.N.T. to L.W.O.S.T.
Occurrence: Annual, Summer.
Reproduction: Unilocular sporangia in Summer.
Notes: Occurs in deep pools in sheltered positions.

Gen. **Castagnea,** Derb. et Sol.

C. virescens, Thur. Common.

Fig.: Harvey I, 55 [as *Mesogloia virescens*].
District: Port Erin; Port St. Mary; Castletown; Douglas Bay (Brady, Talbot).
Zone: M.T. zone pools.
Occurrence: Annual, Summer.
Reproduction: Unilocular sporangia in Summer, beginning at the end of May; plurilocular sporangia in September.

Gen. **Leathesia,** S. F. Gray.

L. difformis, Areseh.

Fig.: Harvey I, 56 [as *L. tuberifornis,* S. F. Gray].
District: In all districts.
Zone: In all zones.
Occurrence: Annual, Summer.
Reproduction: Unilocular sporangia produced all through the Summer; plurilocular sporangia developed at the end of August.
Notes: Found growing on rock surfaces or epiphytically on other algae. Appears in March or April, grows rapidly, reaching its maximum size in July. Plants begin to degenerate early in September.

Fam. *SPOROCHNACEAE.*

Gen. **Sporochnus,** Ag.

S. pedunculatus, Ag. Not common.

Fig.: Harvey I, 21.
District: Peel; Douglas Bay (Mrs. Gatty); Fleshwick Bay; Bay Fine.
Occurrence: Annual, Summer.
Reproduction: Unilocular sporangia in August and September.
Notes: Dredged from deep water or occasionally cast up.

Fam. *CHORDACEAE.*

Gen. **Chorda,** Stackh.

C. filum, Stackh. Common.

Fig.: Harvey I, 30.
District: Port Erin; Port St. Mary; Douglas Bay (Talbot); Peel.
Zone: L.W.O.N.T. and below.
Occurrence: Pseudo-perennial.
Reproduction: Unilocular sporangia in Spring and Summer.
Notes: Forms colonies in sheltered places at low tide zone or in deep low lying pools. Can be found as scattered plants at all times of the year, but most plentiful in Summer.

C. tomentosa, Lyngb.

District: Port Erin.
Note: Recorded by R. J. Harvey-Gibson. No data available.

Fam. *LAMINARIACEAE.*

Gen. **Laminaria,** Lamour.

L. saccharina, Lamour. Common.

Fig.: Harvey I, 27.
District: In all districts.
Zone: L.W.O.N.T.
Occurrence: Perennial.
Reproduction: General.

L. saccharina, var. *Phyllitis,* Le Jol.
Note : Recorded by R. J. Harvey-Gibson. No data available.

L. digitata, Lamour var. *typica,* Foslie. Common.
Fig. : Harvey I, 24.
District : In all districts.
Zone : L.W.O.N.T.
Occurrence : Perennial.
Reproduction : Spring and Summer.
Notes : Forms well-marked belt on flat shores extending into sub-littoral zone.

L. Cloustoni, Edm. Frequent.
Fig. : Hauck, p. 397.
District : Port Erin ; Port St. Mary ; Castletown ; Pooyllvaaish.
Zone : Below L.W.O.S.T.
Occurrence : Perennial.
Reproduction : General.
Notes : Common in deep water with certain amount of shelter.

Gen. **Saccorhiza,** De La Pyl.

S. polyschides, Batt. Not uncommon.
Fig. : Harvey I, 25 [as *Laminaria bulbosa*].
District : In all districts.
Zone : Below L.W.O.S.T.
Occurrence : Perennial.
Reproduction : At any time.

Gen. **Alaria,** Grev.

A. esculenta, Grev. Common.
Fig. : Harvey I, 23.
District : In all districts.
Zone : L.W.O.N.T. and below.
Occurrence : Perennial (or biennial).
Reproduction : Reproductive branches at all times of the year.
Notes : Generally found in positions where water movement is pronounced.

Fam. *CUTLERIACEAE.*

Gen. **Cutleria,** Grev.

C. multifida, Grev.
Fig. : Harvey I, 32.
District : Douglas Bay (Talbot) ; Fleshwick Bay ; Bay Fine.
Zone : Sub-littoral.
Occurrence : Annual, Summer.
Reproduction : Male and female gametangia.
Notes : Dredged from deep water, August 1931. First record since 1890.

Asexual form (**Aglaozonia, Zan.**)

A. reptans, Crn. Rare.

Fig.: Harvey I, 36 [as *Zonaria parvula*]. Plate XVI, 61.
District: Port Erin; Fleshwick Bay.
Zone: M.T. zone and below.
Occurrence: February to September.
Reproduction: Sporangia in Spring and Summer.
Notes: Found on stones in shallow pools, but also on stones dredged from deep water.

Sub-Order. Fucineae.
Fam. *FUCACEAE.*
Gen. **Fucus,** Dene. et Thur.

F. ceranoides, L. Not uncommon.

Fig.: Harvey I, 11.
District: Port Erin; Port St. Mary; Fleshwick Bay.
Zone: H.W.O.N.T. and L.W.O.N.T.
Occurrence: Perennial.
Reproduction: Autumn and Winter.
Notes: Only found where fresh water runs down from the land.

F. spiralis L., var. *platycarpus,* Thur. Common.

Fig.: Oltmanns II, p. 191 [as *F. platycarpus*].
District: In all districts.
Zone: H.W.O.N.T.
Occurrence: Perennial.
Reproduction: From March until November.
Notes: Generally forms a definite zone below the *Pelvetia* zone and above the *Ascophyllum* zone.

F. vesiculosus, L. Common.

Fig.: Harvey I, 10.
District: In all districts.
Zone: M.T. zone and above.
Occurrence: Perennial.
Reproduction: At all times; most abundant in June and July.
Notes: Sometimes occurs in isolated patches but frequently forms a distinct zone (Pooyllvaaish).

F. serratus, L. Abundant.

Fig.: Harvey I, 12.
District: In all districts.
Zone: M.T. zone and below.
Occurrence: Perennial.
Reproduction: Autumn and Winter; occasional in Spring and Summer.
Notes: Forms distinct zone immediately above the *Laminaria* zone except when *Himanthalia lorea* is present.

Gen. **Ascophyllum,** Stackh.

A. nodosum, Le Jol. Common.

Fig.: Harvey I, 13 [as *Fucus nodosus*].

District: In all districts.

Zone: Between H.W.O.N.T. and M.T. zone.

Occurrence: Perennial.

Reproduction: From February onwards.

Notes: Conspicuous in places where rocks are broken up to form boulders: generally forms a definite zone below *Fucus spiralis* and above *Fucus serratus.*

Gen. **Pelvetia,** Dene. et Thur.

P. canaliculata, Dene. et Thur.

Fig.: Harvey I, 16 [as *Fucus canaliculatus*].

District: Port Erin; Perwick Bay; Fleshwick Bay; Pooyllvaaish; Douglas Bay; Peel.

Zone: H.W.O.S.T.

Occurrence: Perennial.

Reproduction: Summer.

Gen. **Himanthalia,** Lyngb.

H. lorea, Lyngb. Locally abundant.

Fig.: Harvey I, 15.

District: Port Erin (Bradda); Port St. Mary; Castletown; Port Soderick (Talbot); Calf (Garner).

Zone: L.W.O.N.T.

Occurrence: Perennial.

Reproduction: From February onwards.

Notes: Forms zone immediately above Laminarian zone.

Gen. **Halidrys,** Lyngb.

H. siliquosa, Lyngb. Frequent.

Fig.: Harvey I, 3.

District: In all districts.

Zone: L.W.O.S.T. and below.

Occurrence: Perennial.

Reproduction: Summer.

Notes: May be found higher up the shore in deep pools. Generally occurs in sheltered situations.

Gen. **Cystoseira,** Ag.

C. ericoides, Ag.

Fig.: Harvey I, 4.

District: Douglas Bay.

Notes: Collected by R. Garner. No data available.

C. discors, Ag.

Fig.: Harvey I, 8.

District: Douglas Bay.

Notes: Collected by R. Garner. No data available.

C. fibrosa, Ag.

Fig.: Harvey I, 7.

District: Douglas Bay.

Notes: Collected by R. Garner. No data available.

Sub-Order. TILOPTERIDEAE.

Gen. **Tilopteris,** Kütz.

T. Mertensii, Kütz. Very rare.
Fig.: Oltmanns II, p. 174.
District: Pooyllvaaish.
Zone: M.T. zone.
Occurrence: Annual, Spring.
Reproduction: Monosporangia and plurilocular sporangia in April. One record only. April, 1931.

Gen. **Achinetospora,** Born.

A. pusilla, Born, var. *crinita,* Batt.
Fig.: Oltmanns II, p. 173.
District: Port Erin; Port St. Mary.
Notes: No data available. Recorded by R. J. Harvey-Gibson.

Sub-Order. DICTYOTEAE.

Fam. *DICTYOTACEAE.*

Gen. **Dictyota,** Lamour.

D. dichotoma, Lamour. Frequent.
Fig.: Harvey I, 38.
District: In all districts.
Zone: M.T. zone and below.
Occurrence: Pseudo-perennial.
Reproduction: Tetrasporic plants prevalent in Autumn; sexual plants in Spring and early Summer. Both types may, however, occur simultaneously.
Notes: Basal parts recognisable in Winter.

D. dichotoma, var. *implexa,* J. Ag. Not common.
Fig.: Harvey I, 38 [as *D. dichotoma* var. *intricata*].
District: Port Erin.
Zone: Cast ashore (probably from deep water).
Reproduction: Tetrasporic plants in Autumn.
Notes: Numerous plants cast ashore in October.

D. ligulata, Kütz.
Notes: Recorded by R. J. Harvey-Gibson for Port Erin and Port St. Mary. No other data available.

Gen. **Dictyopteris,** Lamour.

D. membranacea, Batt. Rare.
Fig.: Harvey I, 33 [as *Haliseris polypodioides*].
District: Port Erin; Douglas Bay (Talbot).
Zone: Dredged in deep water.
Reproduction: Tetrasporic plants in Winter.

RHODOPHYCEAE.

Sub-Order. PORPHYREAE.
Fam. *PORPHYRACEAE.*
Gen. **Erythropeltis,** Schm.

E. discigera, Schm., var. *Flustrae,* Batt. Rare.
Fig.: Plate XIX, 75, 76.
District: Port Erin.
Notes: Epiphytic on *Flustra.* Dredged outside Port Erin Bay.

Gen. **Erythrotrichea,** Aresch.

E. carnea, J. Ag. Frequent.
Fig.: Oltmanns II, p. 234 [as *E. ceramicola*].
District: Port Erin, Port St. Mary.
Occurrence: Sporadic.
Reproduction: Monospores in November.
Notes: Appeared in large quantities, epiphytic on *Cladophora flavescens,* in outside fish tanks of Port Erin Biological Station.

E. Boryana, Berth.
District: Peel.
Notes: Single record. No data available.

Gen. **Bangia,** Lyngb.

B. fuscopurpurea, Lyngb. Frequent.
Fig.: Harvey IV, 345.
District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.
Zone: H.W.O.N.T. to M.T. zone generally.
Occurrence: Pseudo-perennial.
Reproduction: Spring and Summer.
Notes: Common in certain localities. Together with *Urospora sp.* it forms a well-marked zone on large stones at high water mark at Port Erin and Pooyllvaaish. It is also frequent on the walls of the Harbour Works and of the Raglan Pier. It is most noticeable in Spring and Summer. Isolated threads may be found on limpets in Winter.

Gen. **Porphyra,** Ag.

P. coccinea, J. Ag. Very rare.
Fig.: Kuckuck (1897), p. 390.
District: Port Erin.
Zone: Below L.W.O.S.T.
Occurrence: Annual.
Notes: Only occurs as an epiphyte on *Desmarestia aculeata.*

P. leucosticta, Thur. Frequent.
Fig.: Oltmanns II, p. 231.
District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.
Zone: H.W.O.S.T. to H.W.O.N.T.
Occurrence: Annual.
Reproduction: Spring and early Summer.

P. linearis, Grev. Frequent.

Fig.: Harvey IV, 344 [as *P. vulgaris*].

District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish; Douglas Bay (Talbot).

Zone: L.W.O.N.T. to M.T. zone.

Occurrence: Pseudo-perennial.

Reproduction: January and February.

Notes: Common in winter; appears to be the winter form of *Porphyra umbilicalis*, Kutz, var. *laciniata*, J. Ag.

P. umbilicalis, Kutz, var. *laciniata*, J. Ag. Common.

Fig.: Harvey IV, 343 [*as P. laciniata*].

District: In all districts.

Zone: H.W.O.S.T. to H.W.O.N.T.

Occurrence: Pseudo-perennial.

Reproduction: Tetrasporangia in Spring.

Notes: Common in Spring and early Summer; can withstand considerable exposure but is frequently destroyed in Summer when sunny calm weather prevails. Forms a conspicuous zone on smooth rock surfaces usually forming a closed society.

Sub-Order. EUFLORIDEAE.
Fam. *HELMINTHOCLADIACEAE.*
Gen. **Erythrocladia,** Rosenv.

E. subintegra, Rosenv. Rare. (See note 11.)

Fig.: Rosenvinge I (1909), p. 74.

District: Port Erin.

Zone: Dredged in deep water.

Occurrence: Sporadic.

Reproduction: Monospores in March.

Notes: On *Polysiphonia spinulosa*, var. *major* (on *Desmarestia aculeata*).

Gen. **Colaconema,** Batt.

C. reticulatum, Batt. Very rare. (See note 12, p. 114.)

Fig.: Plate XIV, 45.

District: Port St. Mary.

Zone: M.T.

Occurrence: Occasional.

Reproduction: April.

Notes: Endophytic in the walls of young sporelings of an undetermined species of *Cladophora*.

Gen. **Acrochaetium,** Näg.

A. emergens, Rosen. (= *C. emergens*, Rosenvinge.) (See note 14, p. 115) Rare.

Fig.: Rosenvinge (1909), part I, p. 128.

District: Port Erin.

Zone: Dredged in deep water.

Occurrence: Sporadic.

Reproduction: Monospores in May.

Notes: On *Polysiphonia spinulosa*, var. *major* (on *Desmarestia aculeata*).

A. endozoicum, Batt. Rare. (See note 13, p. 114.)

Fig.: Plate XIII, 34, 40.
District: Port Erin.
Zone: L.W.O.S.T.
Occurrence: Sporadic.
Reproduction: Monospores in Spring.
Notes: Parasitic in *Alcyonidium hirsutum* on *Delesseria alata;* recorded March, 1931. Previous record by Professor Darbyshire in April, 1902. In the latter case the *Alcyonidium* was on *Phycodrys rubens.*

A. virgatulum, J. Ag. Not uncommon.

Fig.: Harvey III, 279 [as *Callithamnion virgatulum*].
District: Port Erin; Port St. Mary; Douglas Bay (Brady, Talbot).
Zone: H.W.O.N.T. to M.T. in pools.
Occurrence: Sporadic.
Reproduction: Monospores and tetraspores from January to March.
Notes: Appears spasmodically covering everything within a very short time. Cystocarpia and antheridia not recorded for this area.

A. Daviesii, Näg.

Fig.: Harvey III, 278 [as *Callithamnion Daviesii*].
District: Port St. Mary; Douglas Bay (Mrs. Gatty).
Notes: Recorded by R. J. Harvey-Gibson. No data available.

Gen. **Nemalion,** Targioni-Tozzetti.

N. multifidum, J. Ag. Not common.

Fig.: Harvey III, 218.
District: Port St. Mary; Peel.
Zone: M.T. zone.
Occurrence: Annual, Summer.
Reproduction: Spermatia and Cystocarpia in July and August.
Notes: Found attached to limpet shells in pools. Appears sporadically.

Gen. **Helminthocladia,** J.Ag.

H. purpurea, J. Ag. Rare.

Fig.: Harvey III, 219 [as *Nemalion ? purpureum*].
District: Port Erin; Peel; Douglas Bay (Talbot).
Zone: L.W.O.N.T. to L.W.O.S.T.
Occurrence: Annual, Summer.
Reproduction: Summer.
Notes: Occasional in Port Erin Bay in Summer; large quantity found at Peel in 1913.

Gen. **Helminthora,** J.Ag.

H. divaricata, J. Ag.

Fig.: Hauck, p. 58.
District: Port St. Mary.
Notes: Single record; cast up in Summer.

Fam. *CHAETANGIACÆ*, Schm.

Gen. **Scinaia**, Bivona.

S. furcellata, Bivona.
Fig.: Hauck, p. 62. Harvey III, 210 [as *Ginnania furcellata*].
District: Fleshwick Bay.
Zone: Sub-littoral.
Occurrence: Annual, Summer.
Reproduction: Cystocarps.
Notes: Single record, dredged from deep water August, 1931.

Gen. **Choreocolax**, Reinsch.

C. polysiphoniae, Reinsch. Not uncommon.
Fig.: Plate XVI, 58.
District: Port Erin.
Zone: Same as host.
Occurrence: Sporadic.
Notes: Parasitic on the fronds of *Polysiphonia fastigiata*.

Gen. **Harveyella**, Schm. et Rke.

Fam. *GELIDIACEAE*.

H. mirabilis, Schm. et Rke. Rare.
Fig.: Oltmanns III, p. 487.
District: Port Erin; Port St. Mary.
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: No data.
Notes: Parasitic on the fronds of *Rhodomela subfusca*.

Gen. **Naccaria**, Endl.

N. Wigghii, Endl.
Fig.: Harvey III, 216.
District: Douglas Bay (Mrs. Gatty, Marrat); Fleshwick Bay; Aldrick Bay.
Occurrence: Annual, Summer.
Reproduction: No data.
Notes: Dredged in August.

Gen. **Pterocladia**, J.Ag.

P. capillacea, Born. Very rare.
Fig.: Hauck, p. 191 [as *Gelidium capillaceum*].
District: Castletown.
Zone: M.T. zone.
Notes: Occasional in pools in Summer.

Gen. **Gelidium**, Lamour.

G. crinale, J. Ag., var. *genuinum*, Hauck. Not uncommon.
Fig.: Harvey III, 191 (5) [as *G. corneum*, var. *crinale*].
District: Port Erin; Port St. Mary; Castletown; Peel; Douglas Bay (Talbot).
Zone: H.W.O.N.T. to L.W.O.N.T.
Occurrence: Pseudo-perennial.
Reproduction: In Winter.
Notes: Generally found in exposed situations.

G. pusillum, Le Jol. Frequent.
Fig.: Börgesen, F. Rhodophyceae III, p. 84 (1927).
District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.
Zone: M.T. zone in pools.
Occurrence: Pseudo-perennial.
Reproduction: In Winter.

G. pulchellum, Kütz. Occasional.
Fig.: Harvey III, 191 (4) [as *G. corneum* var. *pulchellum*].
District: Port St. Mary.
Zone: L.W.O.N.T.
Occurrence: Pseudo-perennial.
Reproduction: No data.
Notes: Generally found fringing the margin of tide pools in places shaded by other algae.

G. corneum, Lamour. Not common.
Fig.: Harvey III, 191 (1).
District: Port Erin; Port St. Mary; Fleshwick; Douglas Bay (Talbot).
Zone: H.W.O.N.T. to below L.W.O.S.T.
Occurrence: Pseudo-perennial.
Reproduction: In Winter.

G. latifolium, Born. Frequent.
Fig.: Harvey III, 191 (3) [as *G. corneum* var. *latifolium*].
District: Port Erin; Port St. Mary.
Zone: L.W.O.S.T. and below.
Occurrence: Pseudo-perennial.
Reproduction: Tetraspores and cystocarpia in Winter.
Notes: Found growing on rocks in deep water.

Fam. *GIGARTINACEAE.*

Gen. **Chondrus**, Stackh.

C. crispus, Stackh. Very common.
Fig.: Harvey III, 197.
District: In all districts.
Zone: M.T. zone downwards.
Occurrence: Perennial.
Reproduction: Cystocarpia, spermatia and tetrasporangia in Winter.
Notes: Common everywhere in lower half of littoral zone and extending into deep water. Frequent component of undergrowth of *Fucus* and *Laminaria* species; very variable in form.

Gen. **Gigartina,** Stackh.

G. stellata, Batt. Common.

Fig.: Harvey III, 196 [as *G. mamillosa*].
District: In all districts.
Zone: M.T. zone downwards.
Occurrence: Perennial.
Reproduction: At all times of year.
Notes: Found in same situations as *Chondrus crispus.*

Gen. **Phyllophora,** Grev.

P. epiphylla, Batt. Frequent.

Fig.: Harvey III, 199 [as *P. rubens* Grev.]
District: In all districts.
Zone: M.T. zone to L.W.O.N.T.
Occurrence: Perennial.
Reproduction; Cystocarpia in March.

P. Brodiaei, J. Ag. Very rare.

Fig.: Harvey III, 201.
District: Port Erin; Port St. Mary; Pooyllvaaish.
Zone: L.W.O.N.T. in pools.
Occurrence: Perennial.
Reproduction: No data.

P. palmettoides, J. Ag.

Fig.: Harvey III, 202.
District: Douglas Bay.
Notes: Recorded by Talbot. No data available.

P. membranifolia, J. Ag. Frequent.

Fig.: Harvey III, 202.
District: Port Erin.
Zone: L.W.O.N.T. to L.W.O.S.T.
Occurrence: Perennial.
Notes: Generally found in deep pools; local in distribution.

Gen. **Gymnogongrus,** Martius.

G. Griffithsiae, Martius.

Fig.: Harvey III, 204.
District: Port Erin (Gatty); Douglas Bay (Talbot).
Zone: L.W.O.N.T.
Reproduction: No data.
Notes: Recorded by Batters (1902).

G. Norvegicus J. Ag.

Fig.: Harvey III, 198 [as *Chondrus norvegicus*].
Notes: Recorded by Batters (1902).

Gen. **Ahnfeldtia,** Fries.

A. plicata, Fries. Common.
Fig.: Harvey III, 205 [as *Gymnogongrus plicatus*].
District: In all districts.
Zone: L.W.O.N.T. and below.
Occurrence: Perennial.
Reproduction: Nemathecia in Spring.
Notes: According to Rosenvinge, the so-called parasite, *Sterrocolax decipiens,* is the true nemathecium of the *Ahnfeldtia.*

Gen. **Actinococcus,** Kütz.

A. subcutaneus, Rosenv. Rare.
Fig.: Rosenvinge, 1929. "*Phyllophora Brodiaei* and *Actinococcus subcutaneous.*"
District: Port Erin; Port St. Mary.
Notes: Parasitic on *Phyllophora Brodiaei.* Recorded by R. J. Harvey-Gibson. No other data available. According to Rosenvinge *Actinococcus* is an asexual generation of *Phyll. Brodiaei* growing parasitically on the sexual generation.

Gen. **Sterrocolax,** Schm.

S. decipiens, Schm. Frequent (see note 15, p. 115).
Fig.: Rosenvinge (1930).
District: Same as host.
Zone: Same as host.
Note: Parasitic on *Ahnfeldtia plicata;* see notes under *Ahnfeldtia.*

Gen. **Callophyllis,** Kütz.

C. laciniata, Kütz. Not uncommon.
Fig.: Harvey II, 178 [as *Rhodymenia laciniata*].
District: Port Erin; Port St. Mary; Douglas Bay (Talbot); Peel.
Zone: L.W.O.N.T. and below.
Occurrence: Pseudo-perennial.
Reproduction: Tetrasporic plants predominate in Spring; cystocarpic plants in Summer.

Gen. **Callymenia,** J. Ag.

C. reniformis, J. Ag. Very rare.
Fig.: Harvey III, 211.
District: Port Erin.
Notes: Occasional only; cast ashore.

Fam. *RHODOPHYLLIDACEAE.*

Gen. **Cystoclonium,** Schm.

C. purpureum, Batt. Common.
Fig.: Harvey II, 189 [as *Hypnea purpurascens*].
District: In all districts.

Zone : M.T. zone downwards.

Occurrence : Pseudo-perennial.

Reproduction : Spermatia in Spring : cystocarpia in Summer.

Notes : Very common in pools in the littoral zone in Spring and Summer. Absent from littoral zone in Winter but recognisable on "limpet island" flora in January as minute plants half-inch long. Antheridial plants smaller than the cystocarpic plants.

Gen. **Catenella,** Grev.

C. repens, Batt. Frequent.

Fig. : Harvey III, 214 [as *C. opuntia*].

District : Port Erin, Port St. Mary ; Fleshwick ; Douglas Bay (Brady, Talbot).

Zone : M.T. zone.

Occurrence : Annual, Summer.

Reproduction : Cystocarpia in Summer.

Notes : Forms dark masses lining the crevices of rocks in shady places about half tide zone. Is usually to be found well above the zone of *Lomentaria articulata,* which, apart from colour, it somewhat resembles.

Gen. **Euthora,** J. Ag.

E. cristata, J. Ag. Very rare.

Fig. : Harvey II, 180 [as *Rhodymenia cristata*].

District : Peel ; Douglas Bay (Talbot).

Zone : L.W.O.S.T.

Occurrence : Annual, Summer.

Reproduction : Cystocarpia in Summer ; Tetraspores not recorded.

Gen. **Rhodophyllis,** Kütz.

R. bifida, Kütz. Frequent.

Fig. : Harvey II, 177 [as *Rhodymenia bifida*].

District : In all districts.

Zone : L.W.O.S.T. and below.

Occurrence : Pseudo-perennial.

Reproduction : Tetraspores and cystocarpia at all times of the year ; most abundant in Spring and Summer. Tetraspores and cystocarpia on separate plants.

Fam. *SPHAEROCOCCACEAE.*

Gen. **Sphaerococcus,** Grev.

S. coronopifolius, Grev. Not common.

Fig. : Harvey II, 184.

District : In all districts.

Zone : Below L.W.O.S.T.

Occurrence : Annual, Summer.

Reproduction : Tetraspores and cystocarpia in Summer.

Notes : Though not a rarity this plant occurs as single individuals in deep water. Usually found as a cast-up.

Gen. **Gracilaria,** Grev.

G. confervoides, Grev. Rare.

Fig.: Harvey II, 187.
District: Port Erin; Douglas Bay (Talbot); Pooyllvaaish.
Zone: M.T. zone and below.
Occurrence: Pseudo-perennial.
Reproduction: Cystocarpia in Summer.
Notes: Found only in restricted localities; solitary plants in Winter, locally abundant in Summer.

Gen. **Calliblepharis,** Kütz.

C. ciliata, Kütz.

Fig.: Harvey II, 181 [as *Rhodymenia ciliata*].
District: Douglas Bay (Mrs. Gatty); Peel.
Zone: Below L.W.O.S.T.
Occurrence: Annual, Summer.
Reproduction; No data.
Notes: Deep water form, usually found as a cast-up.

C. lanceolata, Batt. Locally common.

Fig.: Harvey II, 182 [as *Rhodymenia jubata*].
District: Port Erin; Port St. Mary; Castletown; Douglas Bay (Talbot)
Zone: M.T. zone to L.W.O.N.T. in pools.
Occurrence: Pseudo-perennial or perennial.
Reproduction: June and July. Cystocarpia and spermatia recorded.
Notes: Not a conspicuous component of the flora but occurring here and there in fair quantities. Prefers illuminated situations.

Fam. *RHODYMENIACEAE.*

Gen. **Rhodymenia,** J. Ag.

R. palmetta, Grev.

Fig.: Harvey II, 179. var. α.
District: Port Erin.
Notes: Recorded by R. J. Harvey-Gibson. No data available.

R. palmata, Grev., var. *typica,* Batt. Very common.

Fig.: Harvey II, 183. var. α.
District: In all districts.
Zone: L.W.O.N.T. to L.W.O.S.T. and below.
Occurrence: Perennial.
Reproduction: Tetraspores in Winter and early Spring; spermatia in Spring; no record for cystocarpia.

R. palmata Grev. var. *marginifera* Harv.

Fig.: Harvey II, 183. var. β.
District: All districts.
Zone: L.W.O.N.T. to L.W.O.S.T. and below.
Occurrence: Perennial.
Reproduction: See var. *typica* above.
Notes: Forms conspicuous accompaniment to Laminarian zone; frequently attached to *Laminaria* stipes.

Gen. **Lomentaria,** Lyngb.

L. articulata, Lyngb. Common.

Fig.: Harvey II, 146 [as *Chylocladia articulata*].
District: In all districts.
Zone: M.T. zone to L.W.O.S.T.
Occurrence: Perennial.
Reproduction: Tetraspores in Winter; cystocarpia in Spring; single plants bearing tetraspores may be found at all times of the year. Spermatia developed in February and March.
Notes: Common as accompaniment of *Polysiphonia urceolata* and *Plumaria elegans* as a covering to rock surfaces in sheltered positions at low water level or just above; also common component of pool flora.

L. clavellosa, Gail. Frequent.

Fig.: Harvey II, 140 [as *Chrysymenia clavellosa*].
District: In all districts.
Zone: M.T. zone downwards.
Occurrence: Annual, Summer.
Reproduction: Tetraspores in Spring and Summer.
Notes: Found as occasional plants in pools or on rock surfaces. Can be found in February as minute plantlets one-eighth inch high, attached to limpet shells.

L. rosea, Thur., var. *orcadensis,* Harv. Very rare.

Fig.: Harvey II, 141 [as *Chrysymenia rosea,* var. *orcadensis*].
District: Port Erin; Port St. Mary; Perwick Bay.
Zone: M.T. zone to L.W.O.N.T.
Occurrence: Pseudo-perennial.
Reproduction: Tetraspores in Spring and Summer.
Notes: Only occasionally found in Spring and Summer amongst other algae fringing the edge of deep pools. Can be found in the same pools year after year.

Gen. **Champia,** Lamour.

C. parvula, Harv. Rare.

Fig.: Harvey II, 145 [as *Chylocladia parvula*].
District: Port Erin; Douglas Bay (Talbot).
Zone: M.T. zone to L.W.O.N.T.
Occurrence: Annual, Summer.
Reproduction: No data.
Notes: Found in similar situations to *Lomentaria rosea.*

Gen. **Chylocladia,** Grev.

C. kaliformis, Hook. Frequent.

Fig.: Harvey II, 143 (a).
District: In all districts.
Zone: M.T. zone to L.W.O.S.T. in pools.
Occurrence: Annual, Summer.
Reproduction: Cystocarpia in Summer,

C. kaliformis, Hook, var. *squarrosa*, Harv. Very rare.

Fig.: Harvey II, 143 (b).
District: Port Erin.
Zone: No data. Cast ashore.
Reproduction: Cystocarpia in July.

C. ovatus, Batt. Common.

Fig.: Harvey II, 142 [as *C. ovalis*].
District: In all districts.
Zone: M.T. zone to L.W.O.N.T. in pools.
Occurrence: Perennial.
Reproduction: Tetraspores in Spring; cystocarpia in Summer.

Gen. **Plocamium**, Lyngb.

P. coccineum, Lyngb. Common.

Fig.: Harvey II, 175.
District: In all districts.
Zone: L.W.O.S.T. and below.
Occurrence: Pseudo-perennial.
Reproduction: Cystocarpia in Spring and Summer; tetraspores in Summer and Autumn.
Notes: Deep water form; rarely found attached but cast up in large quantities.

Fam. *DELESSERIACEAE*.

Gen. **Nitophyllum**, Grev.

N. punctatum, Grev. Not common.

Fig.: Harvey II, 169.
District: Port Erin; Port St. Mary; Castletown; Douglas Bay (Talbot); Fleshwick Bay.
Zone: L.W.O.N.T.
Occurrence: Annual, Summer.
Reproduction: Tetraspores and cystocarpia in Spring and Summer.

N. uncinatum, J. Ag. Occasional.

Fig.: Kylin, 1924, p. 78 [as *Acrosorium uncinatum*].
District: Port Erin; Port St. Mary.
Zone: L.W.O.N.T. to L.W.O.S.T.
Occurrence: Annual, Summer.
Reproduction: No data.
Notes: Occurs in deep pools in sheltered situations.

N. Gmelini, Grev. Rare.

Fig.: Harvey II, 172.
District: Port Erin; Peel.
Notes: Recorded by R. J. Harvey-Gibson.

N. ramosum, Batt. Frequent.

Fig.: Harvey II, 173 [as *Nitophyllum laceratum*].
District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish; Douglas Bay (Talbot).
Zone: L.W.O.N.T. downwards.
Occurrence: Pseudo-perennial.
Reproduction: Tetraspores in Summer; cystocarpia in Autumn.
Notes: Can be found at all times of the year; most luxuriant growth in Spring and early Summer.

N. ramosum, Batt. var. *uncinatum*, Grev.

Fig.: Cotton (1912), Plate XVIII, 71.
District: Fleshwick Bay.
Notes: Dredged, single specimen only, in August, 1931.

Gen. **Phycodrys,** Kütz.

P. rubens, Batt. Common.

Fig.: Harvey II, 164 [as *Delesseria sinuosa*].
District: In all districts.
Zone: L.W.O.N.T. to L.W.O.S.T.
Occurrence: Perennial.
Reproduction: Tetraspores in Spring; cystocarpia from Spring to Autumn.
Notes: Commonly found epiphytic on the stipes of *Laminaria;* also occurs in pools.

Gen. **Delesseria,** Schm.

D. sanguinea, Lamour. Common.

Fig.: Harvey II, 163.
District: In all districts.
Zone: L.W.O.N.T. downwards.
Occurrence: Perennial.
Reproduction: In Autumn and Winter.
Notes: Can be found at all times of the year but is best from April to June. Basal parts only remain during Winter.

D. alata, Lamour. Very common.

Fig.: Harvey II, 165.
District: In all districts.
Zone: L.W.O.N.T. downwards.
Occurrence: Perennial.
Reproduction: Tetraspores and cystocarpia in Winter and Spring; spermatia only recorded for Spring.
Notes: Very common component of pool and rock flora of lower littoral zone; also occurs in deep water on the stipes of *Laminaria*.

D. angustissima, Griff.

Fig.: Harvey II, 166.
District: Port Erin.
Notes: Recorded by R. J. Harvey-Gibson. No data available.

D. ruscifolia, Lamour. Occasional.

Fig.: Harvey II, 168.
District: Port Erin; Port St. Mary; Perwick; Douglas Bay (Talbot, Brady).
Zone: M.T. zone to L.W.O.N.T.
Occurrence: Perennial.
Reproduction: Cystocarpia in Autumn; tetraspores in Winter.

D. hypoglossum, Lamour. Frequent.

Fig.: Harvey II. 167.
District: In all districts.
Zone: M.T. zone to L.W.O.S.T.
Occurrence: Perennial.
Reproduction: Tetraspores in Winter: cystocarpia in Summer.
Notes: Common component of pool and rock flora; also occurs on stipes of *Laminaria Cloustoni*.

Fam. *BONNEMAISONIACEAE.*

Gen. **Bonnemaisonia,** Ag.

B. asparagoides, C. Ag. Rare.

Fig.: Harvey II, 134.
District: Port Erin; Douglas Bay (Brady, Talbot). Fleshwick Bay.
Zone: Below L.W.O.S.T.
Occurrence: Annual, Summer.
Reproduction: Cystocarpia in July, August and September.
Notes: Cast up material, or dredged from deep water.

Fam. *RHODOMELACEAE.*

Gen. **Rhodomela,** Ag.

R. subfusca, Ag. Common. (See note 17, p. 116.)

Fig.: Harvey II, 100.
District: In all districts.
Zone: M.T. zone to L.W.O.S.T.
Occurrence: Pseudo-perennial.
Reproduction: Cystocarpia, spermatia and tetraspores in Winter and Spring.
Notes: Common in the fringe of algae round margins of pools; disappears at the end of May, but can be found in the sub-littoral zone in the Summer.

R. lycopodioides, Ag. Not common.

Fig.: Harvey II, 99.
District: Port Erin; Port St. Mary; Peel; Douglas Bay (Talbot).
Zone: M.T. zone to L.W.O.N.T.
Occurrence: Annual, Spring.
Reproduction: No data.
Notes; Found in similar situations to *Rhodomela subfusca*.

Gen. **Odonthalia,** Lyngb.

O. dentata, Lyngb. Frequent.

Fig.: Harvey II, 98.
District: In all districts.
Zone: L.W.O.S.T. and below.
Occurrence: Perennial.
Reproduction: Cystocarpia in Spring and Summer; tetraspores in Spring and Autumn.
Notes: This is a plant of deep water situations. It can be found attached in pools at low water level but is more frequently met with as a cast-up.

Gen. **Laurencia,** Lamour.

L. obtusa, Lamour. Frequent.

Fig.: Harvey II, 137.
District: In all districts.
Zone: L.W.O.N.T. downwards.
Occurrence: Annual, Summer.
Reproduction: Cystocarpia and spermatia in August.
Notes: Plant dark red at first but turns yellow with exposure to bright illumination.

L. hybrida, Lenor. Common.

Fig.: Harvey II, 136 [as *L. caespitosa*].
District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.
Zone: M.T. zone to L.W.O.N.T.
Occurrence: Perennial.
Reproduction: Spermatia in Winter; cystocarpia and tetraspores in Spring.
Notes: Very common plant in Spring on the limestone terraces at Port St. Mary. It occurs on limpets, as the floor covering of shallow pools and as a carpet in inter-pool vegetation. It is a perennial with great powers of proliferation.

L. pinnatifida, Lamour. Abundant.

Fig.: Harvey II, 135.
District: In all districts.
Zone: M.T. zone downwards.
Occurrence: Perennial.
Reproduction: Cystocarpia, spermatia and tetraspores in Winter.
Notes: Generally occurs fringing the edges of pools.

Gen. **Chondria,** Ag.

C. tenuissima, Ag. Occasional. (See note 16, p. 116.)

Fig.: Harvey II, 139 [as *Laurencia tenuissima*].
District: Port Erin; Douglas Bay (Talbot).
Zone: L.W.O.S.T.
Occurrence: Annual, Summer.
Reproduction: Tetraspores in Summer; no other data available.

C. dasyphylla, Ag. Occasional.

Fig : Harvey II, 138 [as *Laurencia dasyphylla*].
District : Port Erin ; Peel.
Zone : L.W.O.S.T.
Occurrence : Annual, Summer.
Reproduction : Antheridia in July ; no other data available.

Gen. **Polysiphonia,** Grev.

P. fibrata, Harv.

Fig. : Harvey II, 109.
District : Douglas Bay.
Notes : Recorded by Brady and Batters ; no data available.

P. urceolata, Grev., var. *typica,* J. Ag. Common.

Fig. : Harvey II, 106.
District : In all districts.
Zone : M.T. zone to L.W.O.S.T.
Occurrence : Pseudo-perennial.
Reproduction : Cystocarpia and spermatia in Spring and Autumn ; tetraspores in Winter and Spring.

Notes : Pool alga in mid-tide zone, also component of general rock covering in lower littoral zone. Disappears in early winter but re-attached fragments shew vigorous growth from February onwards.

P. spinulosa, Grev. Very rare.

Fig. : Harvey II, 110.
District : Port St. Mary.
Zone : M.T. zone.
Occurrence : Pseudo-perennial.
Reproduction : Cystocarpia in Autumn.

P. spinulosa, Grev., var. *major,* J. Ag. Not common.

Fig. : Harvey II, 116 [as *P. Carmichaeliana*].
District : Port Erin ; Castletown.
Zone : Same as host.
Occurrence : Annual, Summer.
Reproduction : Cystocarpia in Summer.
Notes : Only found growing as an epiphyte on *Desmarestia aculeata.*

P. elongella, Harv. Rare.

Fig. : Harvey II, 113.
District : Port Erin ; Port St. Mary ; Castletown ; Douglas Bay (Gatty, Talbot).
Zone : L.W.O.N.T. and below.
Occurrence : Pseudo-perennial.
Reproduction : No data.
Notes : On rocks and stones and on the smaller algae near low water mark and at greater depth.

P. elongata, Grev. Common.

Fig.: Harvey II, 114 (2 plates).

District: In all districts.

Zone: L.W.O.S.T. and below.

Occurrence: Perennial.

Reproduction: Cystocarpia in Spring and Summer; tetraspores in Summer, spermatia in Spring.

P. violacea, Grev. Frequent.

Fig.: Harvey II, 115.

District: Port Erin; Port St. Mary; Castletown; Douglas Bay (Brady, Talbot).

Zone: M.T. zone and below in pools.

Occurrence: Pseudo-perennial.

Reproduction: Cystocarpia and spermatia in Spring; tetraspores in Summer.

P. fibrillosa, Grev. Not common.

Fig.: Harvey II, 117

District: Port Erin; Douglas Bay (Mrs. Gatty).

Zone: M.T. zone in pools.

Occurrence: Pseudo-perennial.

Reproduction: In Spring.

P. fastigiata, Grev. Very common.

Fig.: Harvey II, 127.

District: In all districts.

Zone: Same as host.

Occurrence: Perennial.

Reproduction: Cystocarpia at all times of the year; spermatia in Spring and Autumn; tetraspores in Autumn.

Notes: Common everywhere on *Ascophyllum nodosum*.

P. nigra, Batt.

Fig.: Harvey II, 125 [as *P. atro-rubescens*].

District: Douglas Bay, Fleshwick Bay.

Occurrence: Sub-littoral zone.

Reproduction: Cystocarpia in August.

Notes: Recorded by Talbot. Dredged in August, 1931.

P. nigrescens, Grev. Common.

Fig.: Harvey II, 122.

District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.

Zone: M.T. zone and below in pools.

Occurrence: Perennial or pseudo-perennial.

Reproduction: Cystocarpia in Winter and Spring; spermatia only recorded for Spring; no record for tetraspores.

P. Brodiaei, Grev., var. *typica*, Holm et Batt. Frequent.

Fig.: Harvey II, 118.

District: In all districts.

Zone: M.T. zone to L.W.O.N.T. in pools.

Occurrence: Pseudo-perennial.

Reproduction: In Winter and Spring; spermatia abundant.

P. fruticulosa, Spreng. Not common.

Fig.: Harvey II, 105 [as *Rytiphloea fruticulosa*].

District: Port Erin; Port St. Mary; Castletown; Douglas Bay (Brady, Talbot).

Zone: M.T. zone to L.W.O.N.T. in pools.

Occurrence: Perennial.

Reproduction: Spermatia in Spring; cystocarpia in Spring; tetraspores in Summer.

Gen. **Pterosiphonia**, Falk.

P. parasitica, Schm. Rather rare.

Fig.: Harvey II, 128 [as *Polysiphonia parasitica*].

District: Port Erin; Port St. Mary; Castletown; Douglas Bay (Brady, Talbot).

Zone: M.T. zone to L.W.O.S.T.

Occurrence: Perennial or pseudo-perennial.

Reproduction: Although this plant has been examined at all times of the year, no reproductive organs have been observed.

Notes: Found under overhanging ledges in sheltered pools.

P. thuyoides, Schm. Locally common.

Fig.: Harvey II, 104 [as *Rytiphloea thuyoides*].

District: Port Erin; Port St. Mary; Pooyllvaaish; Castletown; Douglas Bay (Brady, Talbot).

Zone: M.T. zone downwards in pools.

Occurrence: Perennial.

Reproduction: Cystocarpia, spermatia and tetraspores in Spring.

Gen. **Brongniartella**, Bory.

B. byssoides, Bory. Common.

Fig.: Harvey II, 129 [as *Polysiphonia byssoides*].

District: In all districts.

Zone: L.W.O.S.T. and below.

Occurrence: Annual, Summer.

Reproduction: Cystocarpia in July and August; tetraspores in September.

Gen. **Dasya**, Ag.

D. arbuscula, Ag. Frequent.

Fig.: Harvey II, 132.

District: In all districts.

Zone: M.T. zone to L.W.O.S.T. in pools.

Occurrence: Perennial.

Reproduction: Cystocarpia and spermatia in Summer; tetraspores in Autumn.

D. ocellata, Harv.

Fig.: Harvey II, 131.

District: Douglas Bay.

Notes: Recorded by Talbot; no data available.

Gen. **Heterosiphonia,** Mont.

H. plumosa, Batt. Common.

Fig.: Harvey II, 130 [as *Dasya coccinea*].
District: In all districts.
Zone: L.W.O.N.T. and below.
Occurrence: Perennial.
Reproduction: Cystocarpia in Summer and Autumn; tetraspores in Autumn.
Notes: Basal parts only to be found in Winter; young shoots appear in March.

Fam. *CERAMIACEAE.*

Gen. **Spondylothamnion,** Näg.

S. multifidum, Näg. Rare.

Fig.: Harvey III, 247 [as *Wrangelia multifida*]. Plate XVII, 63.
District: Port Erin; Peel; Kirk Onchan (Brady); Port Jack (Talbot).
Zone: Below L.W.O.S.T.
Occurrence: Annual, Summer.
Reproduction: Tetraspores in August.

Gen. **Spermothamnion,** Aresch.

S. Turneri, Aresch. Frequent.

Fig.: Harvey III, 252 [as *Callithamnion Turneri*].
District: In all districts.
Zone: M.T. zone to L.W.O.N.T.
Occurrence: Pseudo-perennial.
Reproduction: In Winter.
Notes: Can be found persistently in certain definite localities.

S. barbatum, Born, var. *mesocarpum,* Batt.

Fig.: Harvey III, 276 [as *Callithamnion mesocarpum*].
District: Port Erin.
Notes: Recorded by R. J. Harvey-Gibson. No data available.

Gen. **Trailliella,** Batt.

T. intricata, Batt. Occasional.

Fig.: Rosenvinge (1909), pt. III, p. 306. Plate XIV, 43, 44.
District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.
Zone: M.T. zone to L.W.O.N.T.
Occurrence: Appears to be an annual.
Reproduction: No data.
Notes: Epiphyte on pool algae, chiefly *Corallina officinalis.*

Gen. **Ptilothamnion,** Thuret.

P. pluma, Thur.

Fig.: Harvey III, 254 [as *Callithamnion pluma*].
District: Port Erin.
Note: Single record: epiphytic on *Laminaria* stipe.

Gen. **Griffithsia,** Ag.

G. corallinoides, Batt. Not uncommon.

Fig.: Harvey III, 244 [as *Griffithsia corallina*].

District: Port Erin; Port St. Mary; Castletown; Douglas Bay (Miss Thompson).

Zone: M.T. zone to L.W.O.N.T.

Occurrence: Annual, Spring and Summer.

Reproduction: Cystocarpia, spermatia and tetraspores in July and August.

Notes: Plentiful in some years, hard to find in others.

G. flosculosa, Batt. Frequent.

Fig.: Harvey III, 246 [as *Griffithsia setacea*].

District: In all districts.

Zone: M.T. zone to below L.W.O.S.T.

Occurrence: Pseudo-perennial.

Reproduction: No periodicity in reproduction; tetrasporic plants most abundant; spermatia bearing plants rare.

Notes: Plants growing in deep water very much larger than those found in M.T. pools.

Gen. **Halurus,** Kütz.

H. equisetifolius, Kütz. Not common.

Fig.: Harvey III, 240 [as *Griffithsia equisetifolia*].

District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.

Zone: L.W.O.N.T. to L.W.O.S.T.

Occurrence: Pseudo-perennial.

Reproduction: Spermatia in Autumn.

H. equisetifolius, Kütz, var. *simplicifilum,* J. Ag. Very rare.

Fig.: Harvey III, 241 [as *Griffithsia simplicifilum*].

District: Port St. Mary.

Zone: L.W.O.N.T. to L.W.O.S.T.

Occurrence: Pseudo-perennial.

Reproduction: No data.

Gen. **Monospora,** Solier.

M. pedicellata, Sol. Not common.

Fig.: Harvey III, 273 [as *Callithamnion pedicellatum*].

District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.

Zone: L.W.O.N.T. and below in pools.

Occurrence: Annual, Summer.

Reproduction: In Summer by monospores.

Gen. **Pleonosporium,** Näg.

P. Borreri, Näg. Rare.

Fig.: Harvey III, 266 [as *Callithamnion Borreri*].

District: Port Erin; Douglas Bay (Mrs. Gatty).

Zone: L.W.O.S.T. as an epiphyte.

Occurrence: No data.

Gen. **Rhodochorton,** Näg.

R. membranaceum, Magn.

Fig.: Rosenvinge (1909), Pt. III, p. 393.
District: Port St. Mary.
Notes: Recorded by R. J. Harvey-Gibson. No data available.

R. Rothii, Näg. Common.

Fig.: Harvey III, 274 [as *Callithamnion Rothii*].
District: Port Erin; Port St. Mary.
Zone: H.W.O.N.T. to L.W.O.N.T.
Occurrence: Perennial.
Reproduction: Tetraspores in Spring.
Notes: Common on rocks in crevices or in accumulations of sand or grit.

R. floridulum, Näg.

Fig.: Harvey III, 275 [as *Callithamnion floridulum*].
District: Port Erin; Douglas Bay (Mrs. Gatty).
Notes: No data available.

Gen. **Callithamnion,** Lyngb.

C. byssoides, Arn. Not common.

Fig.: Harvey III, 262.
District: Port Erin; Kirk Onchan (Brady).
Zone: L.W.O.S.T. and below.
Occurrence: Annual, Spring and Summer.
Reproduction: Tetraspores from the end of February onwards.

C. polyspermum, Ag. Frequent. (See Note 18.)

Fig.: Harvey III, 263. Plate XVII, 64.
District: Port Erin; Port St. Mary; Castletown; Douglas Bay (Mrs. Gatty).
Zone: M.T. zone to L.W.O.N.T.
Occurrence: Pseudo-perennial.
Reproduction: Tetraspores in Winter.

C. scopulorum, Ag. Frequent.

Fig.: Plate XVI, 57. Plate XVII, 62.
District: Port Erin.
Zone: H.W.O.N.T.
Occurrence: Pseudo-perennial.
Reproduction: Tetraspores in Winter and Spring.
Notes: Occurs on rocks and stones near high water; very similar to *Callithamnion polyspermum* but smaller; not epiphytic.

C. roseum, Harv. Occasional.

Fig.: Harvey III, 261.
District: Port St. Mary; Douglas Bay (Talbot).
Zone: L.W.O.N.T. to L.W.O.S.T. and below.
Occurrence: Annual, Summer.
Reproduction: Spermatia and tetraspores in Summer; cystocarpia in Spring.

C. Dudresnayi, Crn. Rare.

Fig.: Harvey III, 267 [as *Callithamnion affine*]. Plate XVI, 60. Plate XVII, 65.

District: Port St. Mary.

Zone: L.W.O.N.T. in pools.

Occurrence: Annual, Spring.

Reproduction: Tetraspores in March and April.

C. Hookeri, Ag. Common. (See Note 18, p. 116.)

Fig.: Harvey III, 260.

District: In all districts.

Zone: M.T. zone downwards.

Occurrence: Pseudo-perennial.

Reproduction: Tetraspores, cystocarpia and spermatia in Winter and Spring.

Notes: Plant begins activity in January; usually epiphytic on other algae in pools.

C. Brodiaei, Harv.

Fig.: Harvey III, 256.

Notes: Recorded by Marrat for Isle of Man. No data for locality available.

C. arbuscula, Lyngb. Common.

Fig: Harvey III, 255. Plate XVII, 68.

District: In all districts.

Zone: M.T. zone downwards.

Occurrence: Perennial.

Reproduction: Tetraspores in Autumn: cystocarpia and spermatia in Winter.

Notes: Nearly always found growing epiphytically, generally on *Corallina*.

C. tetragonum, Ag. Not uncommon.

Fig.: Harvey III, 257.

District: Port Erin; Port St. Mary; Castletown; Douglas Bay (Brady, Talbot); Peel.

Zone: L.W.O.N.T. to L.W.O.S.T.

Occurrence: Pseudo-perennial.

Reproduction: Cystocarpia, spermatia and tetraspores in Winter and Spring; the sexual and asexual organs often found on the same plant.

Notes: Generally epiphytic on other algae in low lying pools.

C. brachiatum, Bonnem. Frequent.

Fig: Harvey III, 258. Mathias, 1928. Plate XVIII, 74.

District: Port Erin; Port St. Mary; Castletown; Douglas Bay (Talbot); Peel.

Zone: M.T. zone downwards.

Occurrence: Pseudo-perennial.

Reproduction: Cystocarpia, spermatia and tetraspores in Autumn and Winter.

Notes: Found growing epiphytically on other algae in well-illuminated pools.

C. corymbosum, Lyngb. Not common.

Fig : Harvey III, 271. Plate XVIII, 73.
District : Port Erin ; Port St. Mary ; Castletown ; Douglas Bay (Talbot).
Zone : L.W.O.N.T. to L.W.O.S.T.
Occurrence : Annual, Spring and Summer.
Reproduction : No data.
Notes : In pools epiphytic on larger algae.

C. granulatum, Ag. Occasional.

Fig. : Harvey III, 272 [as *Callithamnion spongiosum*].
District : Pooyllvaaish ; Douglas Bay (Brady, Talbot).
Zone : L.W.O.N.T.
Occurrence : Annual, Summer.

Gen. **Seirospora,** Harv.

S. Griffithsiana, Harv. Rare.

Fig. : Harvey III, 248.
District : Douglas Bay (Miss Thompson).
Zone : Below L.W.O.S.T.
Occurrence : Annual, Summer.

Gen. **Compsothamnion,** Schm.

C. thuyoides, Schm. Rare.

Fig. : Harvey III, 270 [as *Callithamnion thuyoides*].
District : Douglas Bay.
Notes : Recorded by Mrs. Gatty : no data available.

Gen. **Plumaria,** Stachk.

P. elegans, Schm. Common.

Fig. : Harvey III, 224 [as *Ptilota sericea*].
District : In all districts.
Zone : M.T. zone downwards.
Occurrence : Perennial.
Reproduction : Polyspores in Winter and Spring ; carpogonia abundant in March.
Notes : Common everywhere as a rock covering, not so common in pools ; prefers sheltered position in wet crevices or under fucoids ; often found epiphytic on *Laminaria* stipes.

Gen. **Ptilota,** Ag.

P. plumosa, Ag. Common.

Fig. : Harvey III, 223.
District : In all districts.
Zone : L.W.O.S.T. and below.
Occurrence : Perennial.
Reproduction : Tetraspores in Spring and Autumn ; polyspores in Spring ; cystocarpia in Autumn.
Notes : Commonly found on *Laminaria* stipes and in deep pools at low water mark.

Gen. **Antithamnion**, Näg.

A. cruciatum, Näg. Rare.

Fig. : Harvey, III, 250 [as *Callithamnion cruciatum*]. Plate XVII, 66.
District : Port Erin. Fleshwick Bay.
Zone : L.W.O.N.T. and into sub-littoral zone.
Reproduction : Tetraspores in August.
Notes : Cast ashore on *Zostera* in November. Material all sterile.

A. plumula, Thur. Rare.

Fig. : Harvey III, 249 [as *Callithamnion plumula*].
District : Douglas Bay. Fleshwick Bay.
Zone : Sub-littoral.
Occurrence : Found in August and September.
Reproduction : Tetraspores in August, cystocarpia in September.
Notes : Dredged from deep water.

Gen. **Ceramium**, Lyngb.

C. gracillimum, Harv. Rare.

Fig. : Harvey III, 231.
District : Port Erin ; Port St. Mary ; Castletown.
Zone : Below L.W.O.S.T.
Occurrence : Annual, Summer.
Reproduction : No data.
Notes : Generally epiphytic on the larger algae.

C. tenuissimum, J. Ag. Not common.

Fig. : Harvey III, 233 [as *Ceramium nodosum*].
District : Port Erin ; Port St. Mary ; Pooyllvaaish ; Douglas Bay (Talbot).
Zone : L.W.O.N.T. to L.W.O.S.T. in pools.
Occurrence : Annual, Summer.

C. strictum, Harv. Not uncommon.

Fig. : Harvey III, 232.
District : Port Erin ; Port St. Mary.
Zone : L.W.O.N.T. in pools.
Occurrence : Annual, Spring and early Summer.
Reproduction : Tetraspores in Spring.

C. fastigiatum, Harv.

Fig. : Harvey III, 234.
District : Douglas Bay.
Notes : Recorded by Talbot ; no data available.

C. diaphanum, Roth. Not common.

Fig. : Harvey III, 230.
District : Port St. Mary ; Douglas Bay (Brady, Talbot).
Zone : M.T. zone and below in pools.
Occurrence : Annual, Summer.
Reproduction : Cystocarpia in Summer.

C. Deslongchampsii, Chauv. Common.
Fig.: Harvey III, 229.
District: In all districts.
Zone: M.T. zone downwards.
Occurrence: Pseudo-perennial.
Reproduction: In Spring and Summer.
Notes: Common pool alga; regeneration of fragments in early Spring.

C. circinatum, J. Ag.
Fig: Harvey III, 228 [as *Ceramium decurrens*].
District: Douglas Bay.
Notes: Recorded by Mrs. Gatty and Talbot.

C. botryocarpum, Griff.
Fig.: Harvey III, 227.
District: Douglas Bay (Talbot). Port Erin; Pooyllvaaish.
Zone: M.T. in pools.
Occurrence: Pseudo-perennial.
Reproduction: Cystocarpia in Autumn.

C. rubrum, Ag. Very common. (See note 19, p. 117.)
Fig.: Harvey III, 226.
District: In all districts.
Zone: M.T. zone downwards.
Occurrence: Pseudo-perennial between tide marks possibly perennial in deep water.
Reproduction: See note 19.
Notes: Plants healthiest and most abundant in mid-tide pools; also found epiphytic on *Fucus* species, good illumination increases percentage of tetrasporic plants.

C. flabelligerum, J. Ag. Not common.
Fig.: Harvey III, 235.
District: Port Erin; Port St. Mary; Douglas Bay (Talbot).
Zone: M.T. zone to L.W.O.N.T.
Occurrence: Pseudo-perennial.
Reproduction: Spermatia in Winter; tetraspores and cystocarpia not recorded.

C. echionotum, J. Ag. Not common.
Fig.: Harvey III, 236.
District: Port Erin; Port St. Mary; Pooyllvaaish; Douglas Bay (Mrs. Gatty).
Zone: M.T. zone and below in pools.
Occurrence: Pseudo-perennial.
Reproduction: Tetraspores in Summer.

C. ciliatum Ducluz. Not common.
Fig.: Harvey III, 238,
District: In all districts.
Zone: M.T. zone downwards in pools.
Occurrence: Annual, Summer.
Reproduction: No data.

C. acanthonotum, Carm. Frequent.
Fig.: Harvey III, 237.
District: In all districts.
Zone: M.T. zone and below in pools.
Occurrence: Pseudo-perennial or perennial.
Reproduction: Tetraspores in Spring.

Gen. **Microcladia,** Grev.

M. glandulosa, Grev. Occasional.
Fig.: Harvey III, 225.
District: Port Erin; Douglas Bay (Talbot).
Zone: Cast ashore.
Occurrence: Annual, Summer.
Reproduction: No data.

Fam. *GLOIOSIPHONIACEAE.*

Gen. **Gloiosiphonia,** Carm.

G. capillaris, Carm.
Fig.: Harvey III, 217.
District: Douglas Bay.
Note: Recorded by Talbot; no data available.

Fam. *DUMONTIACEAE.*

Gen. **Dumontia,** Lamour.

D. incrassata, Lam. Common.
Fig.: Harvey III, 208 [as *Dumontia filiformis*].
District: In all districts.
Zone: H.W.O.N.T. to below L.W.O.S.T.
Occurrence: Anuual, Spring and early Summer.
Reproduction: Cystocarpia, spermatia and tetraspores in Spring.
Notes: Appears in February but is covered by epiphytes at the end of May; disappears in July and August; sexual plants smaller than tetrasporic plants.

Gen. **Dudresnaya,** Bonnem.

D. verticillata. Le Jol.
Fig.: Harvey III, 220 [as *D. coccinea,* Crn.].
District: Fleshwick Bay; Bay Fine.
Zone: Sub-littoral.
Occurrence: Annual, Summer.
Reproduction: Cystocarpia in August.
Notes: Dredged on stones from deep water.

Gen. **Dilsea,** Stackh.

D. edulis, Stackh. Frequent.
Fig.: Harvey III, 213 [as *Iridaea edulis*].
District: In all districts.
Zone: L.W.O.N.T. to below L.W.O.S.T.
Occurrence: Perennial.
Reproduction: Tetraspores in October and November.
Notes: Occurs in very deep pools and on rocks below low water mark.

Fam. *NEMASTOMACEAE.*

Gen. **Halarachnion,** Schm.

H. ligulatum, Kütz. Rare.

Fig.: Harvey III, 209 [as *Halymenia ligulata*].
District: Port Erin; Port St. Mary; Douglas Bay (Talbot); Fleshwick Bay.
Zone: Sub-littoral.
Occurrence: Annual, Summer.
Reproduction: Cystocarpia in September.
Notes: Dredged.

Gen. **Furcellaria,** Lamour.

F. fastigiata, Lamour. Common.

Fig.: Harvey III, 207.
District: In all districts.
Zone: M.T. zone downwards.
Occurrence: Perennial.
Reproduction: All types of fruiting organs in Spring and Summer.

Fam. *RHIZOPHYLLIDACEAE.*

Gen. **Polyides,** Ag.

P. rotundus, Grev. Not common.

Fig.: Harvey III, 206.
District: In all districts.
Zone: M.T. zone in sandy pools.
Occurrence: Perennial.
Reproduction: No data.

Fam. *SQUAMARIACEAE.*

Gen. **Petrocelis,** J. Ag.

P. cruenta, J. Ag. Not uncommon.

Fig.: Harvey III, 215 [as *Cruoria pellita*].
District: Port Erin; Port St. Mary.
Zone: L.W.O.N.T. to L.W.O.S.T. and below.
Occurrence: Perennial.
Reproduction: Spermatia recorded by R. J. Harvey-Gibson for Summer.

Gen. **Cruoriella,** Crn.

C. Dubyi, Schm. Frequent.

Fig.: Harvey III, 203 [as *Peyssonnelia Dubyi*].
District: Port Erin; Douglas Bay (Talbot).
Zone: M.T. zone downwards.
Occurrence: Perennial.
Reproduction: No data.
Notes: Occurs on rocks and stones at all seasons.

Fam. *HILDENBRANDTIACEAE.*

Gen. **Hildenbrandtia,** Nardo.

H. prototypus, Nardo, var. *rosea,* Kütz. Common.
Fig.: Harvey II, 161 [as *Hildenbrandtia rubra*]. Rosenvinge, 1909. Part II, p. 204.
District: Port Erin; Port St. Mary; Castletown; Douglas Bay (Talbot).
Zone: H.W.O.N.T. to L.W.O.S.T.
Occurrence: Perennial.
Reproduction: Tetraspores in Winter and Spring.
Notes: On rocks and stones in pools.

Fam. *CORALLINACEAE.*

Gen. **Schmitziella,** Born. et Batt.

S. endoploea, Born. et Batt. Not uncommon.
Fig.: Oltmanns III, p. 464.
District: Port Erin; Port St. Mary.
Zone: Same as host.
Occurrence: Annual, Summer.
Reproduction: Summer.
Notes: Found on *Cladophora pellucida.*

Gen. **Melobesia,** Foslie.

M. minutula, Foslie. (See note 20, p. 118.)
Fig.: Rosenvinge, 1909, Part II, pp. 252, 253.
District: Port St. Mary.
Zone: Same as host.
Occurrence: Sporadic.
Reproduction: Spring.
Notes: Found on *Halopteris filicina.*

M. farinosa, Lam.
Fig.: Harvey II, 158.
District: Port St. Mary.
Zone: L.W.O.N.T.
Occurrence: Perennial.
Notes: Recorded by Marrat as epiphytic on *Zostera.*

M. corallinae, Solms.
Fig.: No figure available.
District: Port Erin.
Notes: Recorded by Weiss, 1900.

Gen. **Dermatolithon,** Fosl.

D. pustulatum, Fosl.
Fig.: Harvey II, 159, 160 [as *Melobesia verrucata* and *M. pustulata*].
District: Douglas Bay.
Notes: Recorded by Talbot; no data available.

Gen. **Lithophyllum,** Fosl.

L. incrustans, Fosl. Common.

Fig.: Hauck, Plate I, 4, 5 [as *Lithothamnion polymorphum*].
District: Port St. Mary.
Zone: M.T. zone downwards.
Occurrence: Perennial.
Reproduction: Tetraspores in Winter.

Gen. **Lithothamnion,** Fosl.

L. colliculosum, Fosl, var. *rosea,* Batt.

Notes: Recorded by Weiss 1900.

L. calcareum, Aresch. Common.

Fig.: Harvey II, 153 [as *Melobesia calcarea*].
District: Port Erin; Fleshwick Bay; Port St. Mary.
Zone: Well below L.W.O.S.T.
Occurrence: Perennial.
Notes: Only obtained by dredging. Bottom of Irish Sea round eastern shores of Isle of Man in many places covered with this species.

L. lichenoides, Fosl. Frequent.

Fig.: Harvey II, 156 [as *Melobesia lichenoides*].
District: Port Erin; Port St. Mary.
Zone: M.T. zone downwards.
Occurrence: Perennial.
Reproduction: Tetraspores and cystocarpia in Autumn.
Notes: Found in pools epiphytic on *Corallina.*

L. lichenoides, Fosl, var. *agariciformis,* Fosl. Rare.

Fig.: Harvey II, 155 [as *Melobesia agariciformis*].
District: Dredged off Spanish Head.

L. Lenormandi, Fosl, var. *typica,* Fosl. Frequent.

Fig.: Hauck, 1885, Pl. III, 4. Rosenvinge II, p. 217, 218.
District: Port Erin; Port St. Mary; Castletown; Pooyllvaaish.
Zone: M.T. zone and below.
Occurrence: Perennial.
Reproduction: Tetraspores and cystocarpia in Summer and Autumn.
Notes: Common as a floor covering in pools.

L. membranaceum, Fosl.

Fig.: Harvey II, 157 [as *Melobesia membranacea*].
District: Port St. Mary; Douglas Bay (Talbot).
Occurrence: Perennial.
Reproduction: Tetraspores recorded by R. J. Harvey-Gibson.
Notes: Found on the fronds of *Chondrus crispus.*

Gen. **Phymatolithon,** Fosl.

P. polymorphum, Fosl. Frequent.
Fig.: Harvey II, 152 [as *Melobesia polymorpha*].
District: Port Erin; Port St. Mary.
Zone: M.T. zone downwards.
Occurrence: Perennial.
Reproduction: No data.
Notes: On rocks and stones; very often found growing on limpet shells.

Gen. **Corallina,** Lamour.

C. officinalis, L. Abundant.
Fig.: Harvey II, 147.
District: In all districts.
Zone: M.T. zone downwards.
Occurrence: Perennial.
Reproduction: Tetraspores and cystocarpia in Winter and Spring.
Notes: Common on all coasts except boulder beaches; frequent in pools.

C. squamata, Ellis. Not common.
Fig.: Harvey II, 149.
District: Port St. Mary.
Zone: L.W.O.N.T. downwards.
Occurrence: Perennial.
Reproduction: Tetraspores and cystocarpia in Summer.

C. rubens, Ellis et Solan. Occasional.
Fig.: Harvey II, 150 [as *Jania rubens*].
District: Port Erin; Port St. Mary; Peel.
Zone: H.W.O.N.T. to L.W.O.S.T.
Occurrence: Perennial.
Reproduction: Tetraspores in Spring.
Notes: Epiphytic on the smaller algae on rock surfaces or in pools.

C. rubens, var. *corniculata,* Hauck. Occasional.
Fig.: Harvey II, 151 [as *Jania corniculata*].
District: Port Erin.
Zone: M.T. zone downwards.
Occurrence: Perennial.
Reproduction: In Spring and Summer.
Notes: Epiphytic on the smaller algae in pools, also occurs in deep water.

Gen. **Rhododermis,** Crn.

R. elegans, Crn. Not uncommon.
Fig.: Rosenvinge, (1909) Pt. II, p. 198.
District: Port Erin; Port St. Mary.
Zone: L.W.O.N.T. downwards.
Occurrence: Perennial.
Reproduction: Tetrasporangia developed in Winter.
Notes: Occurs on stones, shells, carapaces of animals and on other algae.

CRITICAL NOTES

1. *Prasiola stipitata.*

Individual plants of this species may grow to large size, reaching some inches in length. In the Port Erin district, however, the only plants found have been quite small, not more than a few cms. in length.

2. *Mikrosyphar polysiphoniae,* Kuck.

Batters' "List of British Marine Algae" in 1902 includes two species of *Mikrosyphar,* namely *M. polysiphoniae* and *M. porphyrae,* neither of which differ greatly from one another in organisation or in reproduction. They have been given specific rank on the basis of their endophytism in different host plants. In examining material on limpet shells collected at Port St. Mary in January and February, 1931, young plants of *Polysiphonia urceolata* showed a rich development of *Mikrosyphar* in the clear outer walls. At the same time thalli exactly similar to those of *Mikrosyphar* on *Polysiphonia* were also to be found in the walls of *Ceramium* sp. and of *Callithamnion arbuscula.* The *Polysiphonia, Ceramium* and *Callithamnion* plants were all growing in close contiguity on the same limpet and it is readily understandable that the *Mikrosyphar* plants had spread from the *Polysiphonia* to the *Ceramium* and *Callithamnion.* As the organisation and reproduction of the *Mikrosyphar* plants appeared to be exactly similar in all three cases it is proposed to regard them all three as specimens of *Mikrosyphar polysiphoniae* and not to make two new species *M. ceramiae* and *M. callithamniae.*

3. *Asperococcus fistulosus,* Hook.
(= *A. echinatus,* Grev.)

In Port Erin and on the neighbouring coast of Port St. Mary and Castletown, two forms of *Asperococcus fistulosus* are to be found. These form-variations present

some puzzling features and it has proved very difficult to decide whether they represent two independent varieties and correspond to *A. fistulosus*, Hook, and *A. fistulosus*, Hook, var *vermicularis*, Griff. recorded by Batters in his "List of British Marine Algae" and described by Harvey in "British Marine Algae," p. 43.

On the Isle of Man coast the two varieties are distinguishable by their difference in size and by the distribution of the sori. One form is attenuated and slightly acuminate and may often be of restricted size. Sterile plants of this type are not easy to distinguish at first sight from young plants of *Scytosiphon lomentarius*. Moreover, the limits of individual sori are lost by confluence of the soral margins so that the whole plant may be covered with crowded sporangia, paraphyses and hairs. Such plants are typical winter forms of the species and persist at somewhat high levels of the shore and round the margins of deep pools at mid-tide zone. They are frequently, though not invariably, covered by a well-marked mantle of mucilage hairs, a feature which is most conspicuous in early spring. The sporangia are almost exclusively plurilocular in character.

During the summer when conditions are more favourable to algal growth, another type of plant agreeing with the form regarded as typical of the species is found. These plants appear about April; they are of sturdier build than their predecessors and gradually invade the pools of the upper and middle regions of the littoral zone. They are characterised by greater size than the winter plants achieve, by well-defined independent sori and by a scarcity of mucilage hairs.

Though these two forms are quite distinct from each other, they are connected by a series of intermediate stages in which the width of the thallus, the definition of the sorus and the copiousness of hair-production are all independently variable.

The co-existence of the two extreme forms in one pool suggests their independence as distinct varieties, but a consideration of the proportional representation of these forms throughout the space of a whole year has led to the conclusion that the narrow form with confluent sporangia and many mucilage hairs is that form of the species in which it survives unfavourable conditions. This form is therefore characteristic of the winter plants and also of those which, in the summer, inhabit the less favourable zones of the littoral region. The existence of the two forms, side by side in spring is due to the fact that individuals of the winter flora persist into the spring season, but their progeny achieve the greater stature of the summer form in response to the more favourable conditions of temperature and illumination, that govern their germination at a period when the sporelings are most sensitive to the factors of illumination and temperature.

From the foregoing it is clear that *Asperococcus fistulosus* is not an annual, as many algologists have considered but is represented throughout the year. Its presence on the shore is maintained by a succession of individuals each with a life-span of a few weeks' duration. Changing physiological conditions of the environment will affect the sensitive sporelings and thus give rise to successive crops whose morphological features vary with the seasons.

That this does not represent the whole matter is made clear by comparison with other areas. Professor Kylin in his "Studien über die Algenflora der schwedischen Westküste" refers to two forms of *Asperococcus echinatus*, namely *F. typica* and *F. villosa*, distinguished from one another by the extreme hairiness and by the confluence of the sori of the latter compared with the scarcity of hairs and clearly distinct sori of *F. typica*. *F. villosa* is also smaller in stature than *F. typica*. In many stations the length of *F. villosa* plants lies between 5 and 10 cms., but

even smaller plants, 1 or 2 cms. in length were found on which the sori were completely merged into a uniform covering of sporangia, paraphyses and hairs, thereby approaching the condition described by Reinke for *A. echinatus* var. *filiformis*. The reduced forms of *F. villosa* are connected to the normal form *F. typica* by a series of intermediates. Professor Kylin suggests that the fluctuating stature and the associated morphological features of sorus-form and hairiness are correlated with variation in salt content of sea-water. This supposition rests on the fact that at the locality where *F. typica* predominates to the exclusion of *F. villosa* the sea-water reaches its maximum salinity for Swedish coasts and approximates to the condition of the sea-water on the Norwegian coast where *F. typica* is the normal form.

The antithesis of a winter plurilocular and a summer unilocular sporangium producing thallus is not mentioned by Professor Kylin for his Swedish plants, but it is a noticeable feature of the Isle of Man plants. The segregation is however indicative of different physiological states of the plants and not attributable to inherent factors since both types of plant have been proved to be diploid in nuclear condition and moreover, in the spring, both types of sporangia are found side by side on the same thallus. The facts of the case are that the small winter plants produce plurilocular sporangia steadily until the spring when they shew unilocular sporangia here and there in the same sorus as plurilocular sporangia. The newly developed summer plants may produce a few plurilocular sporangia at first but they very soon devote themselves exclusively to unilocular sporangium-production.

The life-history of *Asperococcus fistulosus* has been the subject of extended study by Miss H. M. Blackler whose results are incorporated in abbreviated form in this memoir.

The thallus has been shewn to be diploid in every case in which division stages of the somatic nuclei have been obtained. The diploid number has been indicated for the thallus of the small winter form as well as for the large summer form. The plurilocular sporangia are diploid throughout their history and give rise to diploid zoids. The unilocular sporangia are the seat of reduction division and release haploid zoids which function as gametes and thus give rise to diploid thalli once more. Culture of the zygotes has shewn that the first stage of germination is an ectocarpoid filament on which may arise plurilocular sporangia. The zoids released from such sporangia give rise to other filaments similar to the first. These may continue to reproduce by plurilocular sporangia until eventually a series of branches from the creeping filaments give rise to upright threads shewing early signs of longitudinal division and ultimately developing into recognisable *Asperococcus* plants. These plants have been successfully grown in cultures and have produced unilocular sporangia. The intermediate ectocarpoid filament stage is to be interpreted in the light of Professor Sauvageau's culture experiments as a *pléthysmothalle*—an interpolated phase of microscopical dimensions maintaining a succession of individuals by zoids from plurilocular sporangia until such time as conditions permitted the establishment of the macroscopic plant.

Many of the zoids released from the unilocular sporangia do not shew fusion but germinate at once into an ectocarpoid filament. The latter in its turn produces plurilocular sporangia which release haploid zoids. These behave as gametes and by their fusion reinstate the diploid condition and give rise to a diploid filament which may produce diploid plurilocular sporangia or give rise to plantules of *Asperococcus*. This provides a variant of the life-cycle. Both alternatives are indicated in the accompanying diagram of the life-cycle.

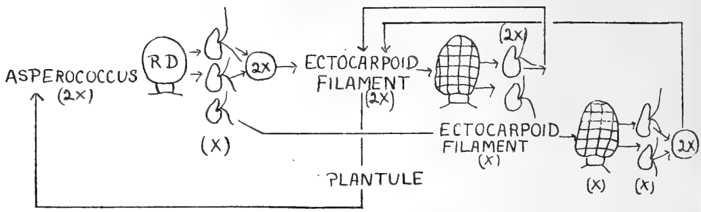

FIG. 1. The Life-Cycle of *Asperococcus fistulosus*.

4. *Minute Ectocarpi.*

In dealing with minute ectocarpoid epiphytes it is essential to know whether the basal layer of the plant is a plate formed of radiating filaments with more or less lateral coherence or whether the upright filaments arise from a branching system of horizontal threads that may be intricately tangled but do not form a pseudo-parenchymatous disc.

To decide this point it is useful to study young plants before the upright filaments make their appearance. If no young stages are available an inspection of the margin of the plant will sometimes provide information.

Care must be taken to discriminate between young stages of the larger species of *Ectocarpus* and mature individuals of minute species of *Ectocarpus* associated genera such as *Streblonema,* etc. The latter have an extensive photosynthetic horizontal thallus which makes up the dominant part of the thallus ; erect filaments are small and for the most part concerned with reproduction. Young stages of larger species have a basal system of pale-coloured or colourless rhizoidal filaments of almost insignificant stature when compared with the sturdy erect filaments that may grow to considerable size before they shew signs of reproduction.

5. *Leptonema fasciculatum,* Rke. var. *majus* Rke.

Plants answering to the description given by Reinke (*Atlas deutscher Meeresalgen*) were found in the lobster

tanks at the Biological Station where they were epiphytic on *Cladostephus* and on the byssi of *Mytilus*. They did not conform to var. *subcylindrica* Rosenv. and had plurilocular sporangia developed on both sides of the filaments and hence did not agree with the description of var. *uncinatum* Rke. It appears therefore that the plants are to be referred to var. *majus*, a variety not hitherto recorded for the British Isles.

6. *Sphacelaria.*

The propagules of the genus *Sphacelaria* are short, lateral branches, tapering towards the base, provided with an apical cell which divides into three or four segments. Each segment then becomes the apical cell of a branch which thus becomes a radiate system of branches any or all of which may grow up into erect photosynthetic shoots or into rhizoidal filaments according to whether they are uppermost or undermost when the propagule leaves the parent plant and comes to rest elsewhere.

7. *Sphacelaria cirrhosa.*

Sphacelaria cirrhosa Ag. var. *fusca* Holm et Batt. is by far the commonest species at Port Erin and on the neighbouring coast. It is particularly conspicuous as a component of the pool flora in the littoral zone where it is frequently found epiphytic on *Corallina* especially in the winter when it is most abundant. The variety *fusca* differs from *Sphacelaria cirrhosa* var. *pennata*, Hauck, which is usually epiphytic on algae from deeper water; as for example, *Desmarestia aculeata* ; it is usually differently divided. Var. *fusca* is less profusely branched and less regularly pinnate ; it also forms irregular mats or tufts from half to one and a half inches in depth, while var. *pennata* forms almost spherical tufts on *Desmarestia* and the fronds are quite regularly pinnate or bi-pinnate. *Sphacelaria cirrhosa* var. *fusca* is almost certainly identical with the

plants referred to by Cotton in the Clare Island Survey, p. 120, which he suggests, may easily be mistaken for *Sphacelaria radicans*. In the Isle of Man district *Sphacelaria cirrhosa* var. *fusca* rarely occurs with sporangia. Occasional unilocular sporangia have been found in the winter but the plant relies chiefly on the production of propagules as a means of spreading. The plants described under the name of var. *fusca* agree with the illustration given in Harvey's "Phycologia Britannica," Vol. I, plate 149, except for the propagules. In Harvey's figure the propagules shew attenuated apices usually regarded as characteristic of branches of limited growth whereas the ends of the radiating branches of the propagules on the Manx plants shew enlarged apices usually associated with branches of unlimited growth.

8. *Sphacelaria bipinnata*, Sauv.

This plant is very similar in habit and general appearance to *Sphacelaria cirrhosa* var. *pennata* Hauck but it is almost restricted to the thalli of *Halidrys siliquosa*. It forms conspicuous globular masses when mature and was therefore originally called *Sphacelaria cirrhosa* var. *ægagropila* by Griffiths. The globular habit is not the result of rolling and tangling of the branches, but is due to regular radiation of the main fronds, hence the name aegagropila is undeserved and has been corrected by Sauvageau to *Sphacelaria bipinnata*. The true aegagropila or rolled form of *Sphacelaria cirrhosa* has not been found in this area.

9. *Ascocyclus*.

Ascocysts distinguish the genus *Ascocyclus* from other genera such as *Myrionema* or small *Ectocarpi* with which it is readily confused by the beginner. Ascocysts are spherical, ovoid, elongate or cylindrical cells filled with a dark brown homogeneous material whose composition and function is somewhat uncertain. See Figure 26.

10. *Mesogloia vermiculata,* Le Jol.

This plant is a summer annual of limited occurrence. It first appears in June as minute plants in well-sheltered localities and grows with great rapidity achieving an increase of a few inches in as many weeks. Plants collected in July, 6-8 inches in length, were plentifully provided with unilocular sporangia. Towards the end of August the plants are readily detached from their hold and washed away. They have almost entirely disappeared from the littoral zone by the middle of September.

Cultural experiments have shewn that the zoids emerging from the unilocular sporangia (haploid) germinate very slowly into minute ectocarpoid filaments bearing plurilocular sporangia. These plants are haploid and serve the function of gametophytes since the zoids from their sporangia fuse in pairs. The union of two similar gametes results in a zygote which germinates into a cellular disc completely adherent to the substratum. Up to the present the discs have shewn only the beginnings of upright filaments that will doubtless eventually develop into the macroscopic *Mesogloia* plants and so complete the life-cycle. *Mesogloia* thus falls into line with the life-cycle of *Laminaria* in possessing a macroscopic asexual phase and a microscopic gametophyte phase. It differs from *Laminaria* in that the macroscopic phase is restricted to the summmer season while the minute phase alone represents the species during the winter.

11. *Erythrocladia subintegra,* Rosenv.

This plant forms minute discs adherent to the walls of *Polysiphonia spinulosa* var. *major* which was found as an epiphyte on *Desmarestia aculeata* dredged from deep water outside Port Erin Bay. The specimens have been examined and identified by Professor Rosenvinge and a description will be found in his papers on the Marine Algae of Denmark, Part I, p. 73.

This species is not included in Batters' List of the British Marine Algae published in the "Journal of Botany" in 1902, and we have not been able to find any record of its occurrence in British waters in subsequent literature; we therefore regard it as an addition to the British flora.

12. *Colaconema reticulatum*, Batt.

Particularly beautiful specimens provisionally referred to this genus were found growing as endophytes in the cell walls of species of *Cladophora* at Port Erin. The species was first described by Batters in the "Journal of Botany," Vol. XXXIV, 1896, p. 8. The specimens which Batters describes were found in the cell-wall of *Desmarestia Dresnayi*. In his description Batters refers to the establishment of a filament with a double row of cells as being due to the limited space between the cells of the host plant in which the endophyte was growing. In the specimen collected at Port Erin on *Cladophora*, the same feature of a double, treble or even four-rowed main filament is clearly shewn, though in this case the plant has had ample room for expansion. The tendency to produce a multicellular central axis is therefore specific to the plant and not a condition imposed by the restrictions of the environment.

13. *Acrochaetium* (*Chantransia*) *endozoicum*, Darb.

The limitations of the genera *Acrochaetium*, *Rhodochorton* and *Chantransia* are by no means clearly defined in the literature. Useful information may be found in a paper by K. M. Drew "A Revision of the genus *Acrochaetium*," Univ. of California. Publ. in Bot., Vol. XIV, No. 5.

Acrochaetium endozoicum was described by Professor Darbishire in the "Ber. der deutsch. bot. Gesell," 1899, and included by Professor Rosenvinge in Part I of the "Marine Algae of Denmark." Neither of the two authors give any information about the chromatophore. In the

material collected at Port Erin a single parietal chromatophore was discernible almost covering the cell wall; a single somewhat indistinct pyrenoid was also to be seen in each cell.

14. *Acrochaetium* (*Chantransia*) *emergens*, Rosenv.

Minute endophytic filaments creeping within the substance of the cell wall of *Polysiphonia spinulosa* var. *major* (itself an epiphyte on *Desmarestia aculeata*) have been identified by Professor Rosenvinge as *Chantransia* (*Acrochaetium*) *emergens*, a species which he described for the first time in his "Marine Algae of Denmark," Part I, p. 128.

This plant corresponds very closely with a specimen described by Batters from material collected by Brebner at Plymouth ("Journal of Botany," 1896, p. 386) under the name of *Acrochaetium endophyticum*. The Plymouth material was endophytic in the cortical layers of *Heterosiphonia coccinea* (*Dasya coccinea*). The difference between the two species appears to be somewhat slight. Apart from the fact that they occur on different host genera, the main point of distinction lies in the length of the erect filaments that emerge through the wall of the host and bear the monosporangia; in *Chantransia emergens* the monospores arise on single-celled filaments and are five to six μ in length by three to four μ in breadth, but in *Acrochaetium endophyticum* the nearly globular monospores are borne on filaments of several cells in length.

In other respects the plants appear to be identical. They may represent two forms of the same species but if they do not, *Acrochaetium emergens*, Rosenv. must be recorded as new to the British algal flora.

15. *Sterrocolax decipiens*, Schm.

There has been in the past much uncertainty as to the exact nature of rounded emergences on the thallus of *Ahnfeltia plicata*. They have alternatively been described

as part of the reproductive processes of the *Ahnfeltia* or as entirely separate plants parasitic on the *Ahnfeltia* thallus. Recently the convergence of three research workers to the view that the emergences are integral parts of the *Ahnfeltia* and concerned with its reproduction, disposes of the "genus" *Sterrocolax*. As it has gained such a place in the literature the name is retained in this list without prejudice to the results of investigation as published by Rosenvinge ("Det. Kgl. Danske Videnskabernes Selskab, X2"), B. D. Gregory ("Annals of Botany" 44, 1930), and E. Chemon, "Bull. de la Soc. bot. de France," 77.

16. *Chondria tenuissima.*

This plant is easily confused with *Rhodomela subfusca* by the inexperienced. The two plants may be distinguished from one another by their anatomical structure.

An illustration of the organisation of the *Chondria* thallus will be found in "Oltmanns," Vol. II, p. 318, fig. 3.

17. *Rhodomela subfusca.*

An illustration of the anatomical features of this plant will be found in "Oltmanns," Vol. II, p. 310, figs. 6 and 7.

18. *Callithamnion Hookeri* and *C. polyspermum.*

Callithamnion species are not easy of identification by the beginner. Some species, as for example, *C. arbuscula* or *C. tetragonum*, are readily recognisable; others are more nearly alike in habit and are distinguishable only by minute differences of proportion or of habit of branching. Some species such as *C. Hookeri* and *C. polyspermum* shew grades of variation of stature and in method of branching within fairly wide limits, with the result that inter-grade forms between the types exist side by side (Fig. 67, Plate XVII; figs. 69, 70, Plate XVIII) and make exact determination difficult.

19. *Ceramium rubrum*, J. Ag.

Ceramium rubrum was the subject of a special study extending over two years from which valuable data was collected bearing on periodicity of reproduction. The plant is a common component of pools in the littoral zone from about half-tide level downwards but specimens attain their maximum size in the sub-littoral zone, as an examination of cast-up material will readily shew.

An analysis of the records shews that periodicity in reproduction is well marked for this plant. Large numbers were collected and examined. In January, February and March it was found that 20 per cent. of the plants were sterile, 30 per cent. bore tetraspores, and 50 per cent. were sexual with antheridia- and carpogonia-bearing plants in approximately equal proportions. From May to August cystocarpic material was abundant and predominated over the tetrasporic plants, but during the autumn the proportion of tetrasporic plants rose to 50 per cent. During the early winter months, November and December, the tetrasporic plants far outnumber the sexual plants. The periodicity is thus clearly marked, giving a preponderance of tetrasporic plants in the winter and an overwhelming majority of cystocarpic plants in the summer, but in neither case is the line of demarcation absolutely clearly cut, since tetrasporic plants persist into the early summer and cystocarpic plants are occasionally found in the winter.

The results obtained from a study of *Ceramium rubrum* thus confirm the view expressed in text books that winter is the period of tetraspore production for the Rhodophyceae and that sexually produced cystocarps are characteristic of the summer. This cycle by no means holds for all Rhodophyceae. For example, *Polysiphonia Brodiaei* shews a complete inversion of this rhythm. The majority of the autumn plants shew tetraspores while a few

individuals shew spermatia. In the winter cystocarpic individuals are in the majority. The plants usually disappear from the flora by the end of May. This lack of conformity to the usually accepted canons of behaviour for Rhodophyceae may possibly be correlated with the fact that *Polysiphonia Brodiæi* is a winter annual in the littoral zone whatever it may do in deeper waters, and makes its first appearance in the pools in October and disappears from the littoral flora by the end of May. The same data have been observed for the periodicity of occurrence and reproduction of *Rhodomela subfusca.* The plant appears in pools of the littoral zone as sporelings in November. By January, these plants have reached a stature of two or three inches and occasional plants bearing spermatia have been recorded for this period. Plants bearing tetraspores are found in March in abundance but from February onwards cystocarpic individuals appear in increasing proportions until May when the plants retreat from the littoral zone. Here again the rhythm is not very clearly defined and is associated with a winter annual habit.

20. *Melobesia minutula,* Foslie.

This minute calcareous alga has been found associated as an epiphyte with the fronds of *Halopteris filicina.* It may possibly be of common occurrence since it is present on Halopteris plants collected at different times from three different localities—Port St. Mary (March), Plymouth (May), and Anglesey (August). The specimens have been examined by Professor Rosenvinge and identified as *Melobesia minutula* Foslie. Under a list of synonyms, Professor Rosenvinge has included the name of *Lithocystis Allmanni,* a genus described by Harvey, "Phyc. Brit." Vol. II, Plate 166. The Port Erin specimens are, however, distinct from *Lithocystis* in that they shew minute cortical cells covering the pericentral walls of the thallus cells.

It is possible that these minute cells escaped observation in Harvey's material as they are difficult to see even under high magnification and with good illumination. In the absence of reproductive structures on Harvey's *Lithocystis* it is impossible to decide whether it is identical with *Melobesia minutula* or not. Neither *Melobesia minutula* nor *Lithocystis Allmanni* appear in Batters' list of 1902. *Melobesia minutula* would therefore appear to be a new record for the British algal flora.

THE ANALYTICAL KEY

In compiling the analytical key the authors have been obliged to relinquish, though with reluctance, the original intention of including the species, and have had to restrict themselves to the genera. This curtailment was made necessary by the fact that there still exists considerable uncertainty about the integrity of many of the species in some of the larger genera. A series of critical studies of such genera as, for example, *Callithamnion*, *Ceramium* or *Cladophora* must be undertaken before any reliable or useful specific key could be established. In the genera cited, species claimed as distinct are linked by so many intergrades that it is difficult to know where one ends and the other begins. For example, *Callithamnion Hookeri* comprises a variety of forms which grade insensibly into a condition recognisable as *Callithamnion polyspermum*. See figures 69, 70.

In constructing the key, keeping in mind the student-public for whose service the memoir is planned, morphological features or salient characters that attract attention have been given first place in diagnostic value. Such characters alone, however, are not in all cases sufficiently discriminative. As a second line of approach therefore, anatomical features have been laid under contribution,

but only as a last resource have the authors had recourse to reproductive structures as a means of distinguishing one genus from another. It is frankly admitted that the result is a distinctly unnatural association of groups of genera—a condition of affairs to be deplored but excusable perhaps on the score of convenience. In extenuation of the policy it may be urged that natural families of algae are founded largely on reproductive structures which may not be present on the material a student wishes to identify. Worse than that, discrimination between algal families sometimes rests on developmental history of complicated reproductive structures, as for example, the cystocarps of the Rhodophyceae. Scrutiny of the mature reproductive plant will yield no evidence of past phases of its development, and to build a key for the use of general botanical students on any such plan would be to assume a theoretical knowledge they might not possess and thus defeat the object of the key, which is to enable the student to arrive with the minimum of mental effort and the maximum precision at a correct identification of his plant.

It must be stated with emphasis that the key is only built to cover the genera as represented by the species present in the flora of the district under discussion. The use of the key for the flora of another area may lead the student into some difficulty.

CHLOROPHYCEAE.

1. Microscopic endophytes or epiphytes; or, if independent plants, not taller than 3 cms. when mature 2
   Macroscopic plants discernible to the naked eye as individuals, or conjointly forming conspicuous masses 7
2. Independent plants attached to rock surfaces 3
   Epiphytes or endophytes 5
3. Plants single "celled," tubular, club-shaped with a long, tapering, colourless stalk ... ... *Codiolum* ...p. 45
   Plants membraneous, ovate or lanceolate, stalked, cells in groups or packets embedded in colourless matrix *Prasiola* ...p. 45
   (See note 1, p. 105.)
   Plants tubular, branched or unbranched 4

4. Plants usually unbranched, cells in regular longitudinal and horizontal rows, cells grouped in fours, each group surrounded by a definite membrane and embedded in a colourless matrix *Capsosiphon aureolus* ...p. 46

Plants branched or unbranched, cells small and irregularly arranged *Enteromorpha micrococca* or young stages of other species ...p. 47

5. Thallus discoid, closely applied to the thalli of other algae *Pringsheimia* ...p. 45

Thallus of microscopic filaments growing in or on animals, shells or other algae 6

6. Filaments embedded in shells ... ... *Gomontia* ...p. 54

Filaments immersed in the walls or creeping over the surface of animals (Flustra, Sertularia, Alcyonidium, etc.), or other algae ... ... *Endoderma* ...p. 49

7. Thallus a plane membrane; or formed by compression of a tubular thallus 8

Thallus filamentous, cells uninucleate or multinucleate, but not completely coenocytic 12

Thallus of various forms, built up of coenocytic threads; no cross-walls except where reproductive organs are found ... 11

8. Thallus a membrane, one cell layer in thickness 10

Thallus a membrane, two cell layers in thickness *Ulva* ...p. 48

Thallus tubular throughout, flattened or cylindrical, branched or unbranched 9

9. Plants usually unbranched, cells in regular horizontal and longitudinal rows, grouped in fours, each group surrounded by a membrane and embedded in a colourless matrix ... *Capsosiphon aureolus* ...p. 46

Plants branched or unbranched, cells small and irregularly arranged ... ... *Enteromorpha* ...p. 47

10. Thallus delicate in texture, tubular only when young, cells not shewing marked regularity in arrangement. *Monostroma* ...p. 46

Thallus a membrane usually only few cms. long, cells arranged in definite groups or packets embedded in colourless matrix *Prasiola* ...p. 45

11. Thallus of irregular coenocytic filaments, sparingly branched, not woven together to give a definite shape to the plant *Vaucheria* ...p. 55

Thallus of coenocytic filaments with a main axis and lateral branches more or less pinnately arranged ... *Bryopsis* ...p. 54

Massive thallus of sponge-like consistency, formed of interwoven, much branched, coenocytic filaments with dilated apices *Codium* ...p. 55

12. Filaments unbranched, microscopically fine, somewhat slimy to the touch 13
    Filaments coarse, visible to the naked eye as threads, branched or unbranched 14

13. Filaments of a single row of cells, of uniform width throughout, with band-shaped chromatophores and conspicuous pyrenoids in each cell ... ... *Ulothrix* ...p. 48
    Filaments of a single row of cells, of varying diameter, only the narrowest shewing band-shaped chromatophores. Wider parts of the filaments divided into narrow discoid or completely spherical cells (usually reproductive) ... *Urospora* ...p. 49

14. Filaments branched 15
    Filaments unbranched 16

15. Thallus of two to four rows of cells, forming a multicellular filament, sometimes twisted, not hollow and only occasionally branched ... ... *Percursaria* ...p. 46
    Thallus branched, tubular, formed of small cells arranged as in parenchyma ... ... *Enteromorpha* ...p. 47
    Thallus of semi-coenocytic filaments forming a tangled mass; filaments provided here and there with short, recurved, hook-like branches ... ... *Rhizoclonium* ...p. 51
    Thallus of semi-coenocytic filaments with a high degree of branching ... ... *Cladophora* ...p. 52

16. Filaments of a single row of large semi-coenocytic cells... *Chaetomorpha* ...p. 50
    Filaments two to four cells in breadth, sometimes twisted, not forming a tube ... ... *Percursaria* ...p. 46

PHAEOPHYCEAE.

A Filamentous plants not microscopically small, monosiphonous except perhaps where fine corticating filaments clothe the base of the main axis; plants forming tufts attached by a system of rhizoidal filaments to rock surfaces or the thalli of other algae 1

B Minute filamentous plants creeping within the tissues of animals or other algae; or forming crusts, discs, patches, hemispherical or brush-like tufts of small size (not more than a half inch long) on the thalli of other algae, on animals or on rock surfaces ... 3

C Filamentous thalli, monosiphonous only in early stages and at the tips of the branches. Cortication by longitudinal division of the original filaments which are not provided with an enlarged and conspicuous apical cell 12

D Thallus much branched, somewhat bristly and stiff, branches monosiphonous at the apices only; clothed with extremely regular corticating cells which may be overlaid by a system of irregular creeping filaments; branches pinnately arranged or whorled, some at least bearing a conspicuous, enlarged, apical cell, several times larger than the cell next below. Plants frequently bearing propagules (see note 7, p. 111) 15

E Plants completely hollow, at least when mature; either irregularly distended into spherical sacs, or elongated into tubular thalli branched only at the base 18

F Thallus of an organisation other than any included in the above alternatives 21

1. Unilocular and (or) plurilocular sporangia as lateral appendages either stalked or sessile ... ... *Ectocarpus* ...p. 60
Plurilocular sporangia as lateral appendages. Unilocular sporangia in pairs or whorls formed by transformation of lateral segments of the cells of the filament *Isthmoplea* ...p. 64
Unilocular and plurilocular sporangia in the course of the filament and not as lateral appendages... 2

2. Sporangia formed by transformation of series of consecutive cells of the filaments ... ... *Pylaiella* ...p. 63
Plurilocular sporangia in the course of the filament; large monospores formed singly or in pairs by transformation of certain cells of the filament ... ... *Tilopteris* ...p. 75
(See also *Achinetospora*, p. 75)

3. Thallus forming crusts on rock 5
Thallus forming discs, patches, pustules, tufts, or brush-like coverings to other algae 6
Thallus quite inconspicuous, consisting of irregularly branched horizontal filaments creeping on or in the walls of larger algae or animals, giving off sporangia or hairs as upright branches 4

4. Filaments creeping among the cortical cells of other algae (*Castagnea*, etc.) or on animals (*Flustra*, *Alcyonidium*), giving off as upright branches sporangia and hairs ... *Streblonema*. ...p. 60
(See note 4, p. 110 and also *Ectocarpus parasiticus* and *Myrionema aecidioides*)
Filaments creeping within the substance of thick-walled Rhodophyceae such as *Polysiphonia urceolata* *Mikrosyphar* ...p. 56

5. Basal plate from which arise upright filaments closely pressed together; unilocular and plurilocular sporangia formed by direct transformation of apical cells of the filaments *Lithoderma* ...p. 69
Basal plate covered by pseudo-parenchymatous tissue, from which arises a covering of free filaments; unilocular and plurilocular sporangia as lateral branches from the base of free filaments arranged in sori ... ... *Ralfsia* ...p. 69

Thallus in form of horizontal crust of parenchymatous organisation, attached to the substratum by rhizoids; central cells large, surface cells small and regular. (These surface cells are not to be confused with the closely packed terminal cells of upright filaments which are not present in this plant) ... *Aglaozonia* ...p. 73

6. Filaments monosiphonous 7
Filaments multicellular, cylindrical and unbranched *Litosiphon* ...p. 57

7. Free filaments short, of approximately uniform length, standing very close together and arising from a one-layered (or occasionally two-layered) cellular plate (see note 4) 11
Free filaments forming hemispherical or elongated tufts, not arising from a one-layered basal plate 8

8. Free filaments arising from horizontally creeping threads ... 9
Free filaments arising from a dense core of compressed, almost colourless, pseudo-parenchymatous tissue 10

9. Free filaments (quarter to half inch long) arising in tufts; plurilocular sporangia formed by transformation and lateral extension of intercalary cells of the filaments; unilocular sporangia very large arising as lateral branches from the base of the filaments ... ... *Leptonema* ...p. 66
Free filaments of unequal length arising irregularly from creeping filaments, bearing sporangia as lateral branches or terminally, some upright branches may be sterile and others transformed into colourless hairs.
Minute parasitic or epiphytic species of *Ectocarpus* (see note 4, p. 110) ... ...p. 60

10. Core of closely woven pseudo-parenchymatous tissue covered by free assimilatory filaments of approximately equal length, bearing sporangia as lateral branches from their bases ... *Myriactis* ...p. 65
Core of colourless pseudo-parenchyma covered by radiating filaments of two kinds :—
(*a*) Short club-shaped assimilators, with unilocular and (in some species) plurilocular sporangia as lateral branches from the base and
(*b*) longer branches of much larger cells ... *Elachista* ...p. 65

11. Basal plate one cell thick throughout, covered by short, unbranched, upright assimilatory filaments; unilocular and plurilocular sporangia direct from the basal plate; plurilocular sporangia with one or more rows of loculi *Myrionema* ...p. 68
Basal plate one cell thick throughout, with or without upright assimilatory filaments, but giving rise to sporangia, hairs and ascocysts (see note 10); plurilocular sporangia with one row of loculi ... ... *Ascocyclus* ...p. 69

Basal plate in places two cells thick, giving off assimilatory filaments, mucilage hairs and sporangia; plant attached by rhizoids penetrating into the tissues of a host plant ... *Ulonema* ...p. 68

Basal plate in places two cells thick, giving off short filaments with terminal sporangia, or longer filaments with lateral sporangia ... ... *Hecatonema* ...p. 69

Basal plate two cells thick, giving off upright filaments and sporangia in separate groups, surrounded by a sterile area... *Chilionema* ...p. 69

12. Thallus thread-like, cylindrical, solid or hollow polysiphonous when mature, even before sporangia are formed 13

Thallus thread-like, cylindrical, solid, monosiphonous in young stages, becoming polysiphonous first at nodes where sporangia form ... ... *Phloeospora* ...p. 57

13. Small epiphytes about a half inch long 14

Larger algae sparingly branched ... *Stictyosiphon* ...p. 57

14. Cylindrical parenchymatous, unbranched filaments, surface cells transformed into scattered unilocular or plurilocular sporangia, without much distortion of the smooth outline of the filament ... ... *Litosiphon* ...p. 57

Club-shaped filaments thickly beset with :—

(*a*) transparent hairs, and (or)

(*b*) short conical branches often transformed into stumpy plurilocular sporangia and (or)

(*c*) distended unilocular sporangia ... *Myriotrichia* ...p. 64

15. Branches coming off all round the stem or in definite whorls, giving the plant the appearance of a bottle-brush ... *Cladostephus* ...p. 67

Branches more or less pinnately arranged, not whorled... ... 16

16. Thallus irregularly pinnate, super-cortication of rhizoidal filaments at extreme base of main axis, sporangia singly as lateral appendages and not in the axils of branches ... *Sphacelaria* ...p. 66

(See note 6, p. 111.)

Rhizoidal filaments forming an investment to most of the branches, sporangia in the axils or on special reproductive ramuli 17

17. Vegetative axes bi-pinnately branched, pinnules arising in pairs from each, or every alternate cell of the pinnae; sporangia borne on short compound branches originating from cortical cells of main axis near the apex *Chaetopteris* ...p. 67

Vegetative axes pinnately branched (bi- or tri-pinnate), all branches arising by segmentation of the apical cell; sporangia singly in the axils of branches ... *Halopteris* ...p. 67

Vegetative axes densely corticated by intricately woven filaments ; main branches arising all round the stem, making a very dense and bushy plant ; secondary branches pinnate ; sporangia in groups hidden in the axils of branches ... *Stypocaulon* ...p. 68

18. Thallus elongated and tubular 20

Thallus rounded, irregularly lobed or sub-spherical 19

Thallus forming a stalked "button" frequently hollow, from the centre of which spring forked thongs bearing conceptacles of oogonia and antheridia ... ... *Himanthalia* ...p. 74

19. Thallus at first solid, but soon becoming hollow, shewing two layers of tissue, the outer of which consists of radially arranged, monosiphonous assimilating threads ... *Leathesia* ...p. 71

Thallus hollow, of two layers of tissue, the outer of which is apparently parenchymatous ... ... *Colpomenia* ...p. 59

20. Thallus branched only at the base, cylindrical, regularly constricted at intervals, tapering towards the apex, small cells on surface transformed into sporangia but not localised into definite sori ... ... *Scytosiphon* ...p. 59

Thallus irregularly distended, often wider towards the apex, dotted all over with sori of colourless hairs and sporangia *Asperococcus.* ...p. 59 (See note 3, p. 105.)

Thallus branched, branches either opposite or in whorls ; unilocular sporangia developed on the surface in whorls or in patches ... ... *Striaria* ...p. 58

Thallus at first solid, later hollow ; cells of the axis increasing in size towards the periphery, but covered externally by a single layer of small cells ; unilocular sporangia in external sori, accompanied by groups of club-shaped filaments forming minute dark-coloured warts over the surface *Stilophora* ...p. 70

21. Small thalli forming globular or irregularly lobed gelatinous masses less than 2½ inches in diameter. Surface layer of the plant formed of radially arranged assimilatory filaments *Leathesia* ...p. 71

Thallus smooth, unbranched solid and whip-like, slippery to the touch, 1-6 feet or more in length. ... *Chorda* ...p. 71

Thallus 3-10 inches long, branched, of extreme slipperiness ; with a core of more or less coherent colourless filaments of large cells and a cortical mantle of radially arranged, club-shaped, monosiphonous branches, more or less separable under pressure 22

Thallus of other organisation 23

22. Irregularly branched thallus, gelatinous, built up of central core of longitudinal rows of large colourless cells, not interwoven by horizontal filaments ... ... *Castagnea* ...p. 70

Irregularly branched, gelatinous thallus built up of a central core of filaments of large cells interwoven by fine threads running in all directions ; an inner cortex of cells decreasing in size towards the periphery and giving rise to corticating assimilatory filaments arranged in groups *Mesogloia* ...p. 70

A smooth, cylindrical, branched thallus, about $\frac{1}{8}$ inch in diameter, built up of a central core of solid tissue, large and small cells packed together ; cortex of *very* small compact, assimilatory filaments not easily separable under pressure *Chordaria* ...p. 70

23. Reproductive organs (oogonia and antheridia) sunk in conceptacles relegated to tips of fronds or borne on special lateral branches (receptacles) ... ... (Fucaceae) 24

Reproductive organs not as above, or plant without receptacles 27

24. Lower part of thallus in form of stalked disc with long forked strap-shaped receptacles springing from its centre ... *Himanthalia* ...p. 74

Thallus flat, ribbon-like, much divided ; air-bladders, if present, in the course of the frond 26

Thallus cylindrical, more or less flattened 25

25. Thallus with large oval air-bladders in the course of the main axes ; ovoid receptacles on short lateral branches, arranged in groups ... ... *Ascophyllum* ...p. 74

Thallus pinnately branched ; long pod-like air-floats divided by septa ; receptacles on narrow forked branches ... *Halidrys* ...p. 74

Thallus finely divided, usually narrow (thickness of string), frequently covered with spiny emergences ; air bladders small, not very distinct, arranged in chains distending the finer branches ... ... *Cystoseira* ...p. 74

26. Small plants, 2-6 inches long, without air-bladders, growing at high water mark; channelled thallus hanging from rock with convex surface outermost ... ... *Pelvetia* ...p. 74

Larger algae, with or without air-bladders, not channelled ; receptacles terminal on divisions of the thallus *Fucus* ...p. 73

27. Plant a stalked disc of about 1 inch diameter *Himanthalia* ...p. 74

Small plant, 2-6 inches long, without air-bladders, growing at high water mark ; channelled thallus hanging from rock with convex surface outermost ... ... *Pelvetia* ...p. 74

Plants provided with definite air-floats 28

Plants not provided with definite air-floats 30

28. Thallus flat, ribbon-like, much divided, air-floats in the course of the frond ... ... *Fucus* ...p. 73

Thallus cylindrical, more or less flattened 29

29. Thallus with large ovoid air-bladders in the course of the main axis ; ovoid receptacles on short lateral branches, arranged in groups ... ... *Ascophyllum* ...p. 74

Thallus pinnately branched ; long pod-like air-floats divided by septa ; receptacles on narrow forked branches *Halidrys* ...p. 74

Thallus finely divided, usually narrow (thickness of string), frequently covered with spiny emergences ; air-bladders small, not very distinct, arranged in chains distending the finer branches ... ... *Cystoseira* ...p. 74

30. Thallus expanded into a membrane, a lamina or a ribbon ; branched or unbranched ; with or without a stem-like portion 31

Thallus cylindrical or slightly flattened, branched or unbranched, not exceeding a quarter inch in diameter 39

31. Thallus more than 15 inches long when mature 32

Thallus less than 15 inches long when mature 35

32. Thallus provided with a midrib 33

Thallus without a midrib 34

33. Thin membranous papery frond with conspicuous yellow midrib, and if reproducing, a bunch of tongue-like branches, 3-8 inches long, arising from the stalk below the frond ... *Alaria* ...p. 72

Thallus ribbon-like, much branched, with serrated margins and marked midrib; thallus covered with groups of mucilage hairs *Fucus serratus* ...p. 73

34. Large leathery fronds without midrib ; stalk circular or slightly ovoid in section ; no mucilage hairs on the lamina ... *Laminaria* ...p. 71

Large leathery fronds with a stalk distinctly flattened into a strap $1\frac{1}{2}$-$3\frac{1}{2}$ inches broad, sometimes with frilled lateral wings ; base irregularly bulbous covered with short tubercles ; mucilage hairs on lamina ... ... *Saccorhiza* ...p. 72

35. Thallus undivided, lanceolate, often pointed at the apex ... 36

Thallus dichotomously or otherwise divided 37

36. Sori of unilocular and plurilocular sporangia (either or both) forming flecks or spots on the thallus ; substance somewhat delicate in texture ... ... *Punctaria* ...p. 58

Plurilocular sporangia formed without much distention of surface cells over large areas of the thallus ; substance of the thallus tough ... ... *Phyllitis* ...p. 58

37. Thallus without midrib, more or less dichotomously divided, becoming markedly narrower towards the ends of the fronds, which are almost linear ; sori of stalked plurilocular gametangia scattered over the surface of the thallus *Cutleria* ...p. 72

Thallus dichotomously divided, either with a midrib or with fronds not conspicuously narrowed towards the apices ... 38

38. Frond with a midrib ... ... *Dictyopteris* ...p. 75
Frond without a midrib ... ... *Dictyota* ...p. 75

39. Small plants less than 2 inches long, thin and wiry, growing on the leaves of Zostera ... ... *Phyllitis zosterifolia* ...p. 58
Thallus branched mostly at the base, narrow, whip-like; composed of a solid core of large and small cells surrounded by a cortical mantle of short, narrow, closely packed, radial assimilatory filaments ... ... *Chordaria* ...p. 70
Thallus without complete mantle of radial assimilatory filaments 40

40. Thallus traversed by a distinct axial row of cells (transverse section of main axis shows a single, *thick-walled*, though not necessarily large cell in the middle); plant often covered by brush-like tufts of fine silky hairs ... *Desmarestia* ...p. 55
Thallus without an axial row of cells 41

41. Cylindrical branched plant, beset with ovoid bodies, crowned with a tuft of hairs and containing branched filaments bearing unilocular sporangia ... ... *Sporochnus* ...p. 71
Plant without ovoid sporangia-containing bodies 42

42. Thallus much branched, forming bushy plant from 6-8 inches long; unilocular sporangia sunk in the cortical tissue, not protruding *Dictyosiphon* ...p. 56
Thallus hollow; branches opposite or in whorls; cells large; surface cells transformed into unilocular sporangia in whorls, making transverse bars visible to the naked eye *Striaria*...p. 58
Thallus at first solid, later hollow; cells of the axis increasing in size towards the periphery, but covered externally by a single layer of small cells; unilocular sporangia in sori, accompanied by groups of club-shaped filaments, forming minute dark-coloured warts over the surface *Stilophora* ...p. 70
Thallus solid, much branched, eventually covered by whorls of tufted hairs, from which arise as lateral branches bead-like chains of unilocular sporangia ... ... *Arthrocladia* ...p. 64

RHODOPHYCEAE

1. Thallus encrusted with calcium 2
Thallus not encrusted with calcium 5

2. Thallus expanded horizontally, encrusting rock or other algae; attached by the whole under surface, or with free margins, or attached at one point only; irregular coral-like branches without regular constrictions may arise from the horizontal portion 3
Thallus not expanded horizontally, but erect, branched and regularly constricted into an articulated thallus *Corallina* ...p. 104

3. Thallus a plate, originally one cell-layer in thickness but becoming several layered (1-5) in places by means of horizontal divisions; cystocarps in raised pustules; tetraspores in conceptacles ... ... *Melobesia* ...p. 102

Thallus a minute plate (2-10 mm. in diameter) of two cell layers; cells of underlying layer elongated in vertical direction, and each capped by a small cell of the upper layer; zonately divided tetraspores in conceptacles with an apical pore ... *Dermatolithon* ...p. 102

Thallus many cells in thickness, sometimes differentiated into distinct strata with cells elongated in various directions ... 4

4. Thallus encrusting or sometimes forming overlapping or even vertically arranged lamellae; tissue showing curved zones in vertical section (see fig. 110 in Hauck, p. 268); tetraspores in special marginal conceptacles with sieve-like apertures ... *Lithophyllum* ...p. 103

Thallus encrusting or forming coral-like growths; tissues in strata, of which the underlying is as in *Lithophyllum*, but the upper strata are composed of cells arranged in regular vertical rows (see fig. 112, Hauck, p. 272); tetraspores in groups superficially placed or only slightly sunk in the thallus ... *Lithothamnion* ...p. 103

Thallus encrusting, of the same organisation as *Lithothamnion*, but with tetraspores in scattered groups deeply embedded in the tissues, conceptacles opening by sieve-like apertures ... *Phymatolithon* ...p. 104

5. Minute filamentous algae creeping in or on the walls of animals or other algae, rarely giving off upright free filaments except when reproducing 6

Minute plants forming extensive plates or stain-like patches on rock or other algae; thallus an expanded basal plate from which arise vertical filaments of uniform height or a solid pseudo-parenchymatous mass 8

Thallus of various forms but neither encrusting nor endophytic... 10

6. Thallus endozoic in the walls of *Alcyonidium*; monosporangia on short free filaments emerging from the *Alcyonidium* wall *Acrochaetium endozoicum* ...p. 78

Thallus endozoic in *Sertularia*; cruciately divided tetraspores on vertical filaments emerging through the Sertularia wall *Rhodochorton membranaceum* ...p. 95

Thallus endophytic in the walls of *Cladophora rupestris*, etc.; tetraspores, often in twos, formed under the surface of the host wall; sometimes emergent *Schmitziella endophloea* ...p. 102

Thallus endophytic in the walls of various algae, forming a network; reproduction by monospores cut off from cells of the filament; not emergent ... ... *Colaconema* ...p. 77

Thallus endophytic in the walls of Polysiphonie, etc., giving off monospores from emergent branches ... *Acrochaetium* ...p. 77

Minute filamentous epiphytes of extremely small size forming discs or patches on the surface of other algae, *Flustra*, etc.; reproduction by monospores cut off by a curved wall arising within a thallus cell 7

7. Discs made up of clearly recognisable filaments free from one another at their apices ... ... *Erythrocladia* ...p. 77

Discs made up of confluent filaments forming pseudo-parenchyma with an entire margin ... *Erythropeltis* ...p. 76

8. Free filaments more than quarter inch in length 20

Free filaments less than quarter inch in length 9

9. Thallus with a basal layer from which arise free vertical threads with cruciately divided tetraspores in the course of the filaments ... ... *Petrocelis* ...p. 101

Thallus similar to above but with short tapering vertical filaments united into a pseudo-parenchymatous layer, but readily separable under pressure; cruciately divided tetraspores terminal on short filaments interspersed among the rest ... ... *Cruoriella* ...p. 101

Thallus completely attached to the substratum, formed of minute cells united into pseudo-parenchyma, not separable under pressure; tetraspores cruciately or zonately divided, in conceptacles buried in the thallus but opening to the surface by a pore ... ... *Hildenbrandtia*... p. 102

Thallus with a basal plate from which arise vertical filaments, 12-30 cells long; not readily separable under pressure, giving rise above to sori of cruciately divided tetraspores and paraphyses ... ... *Rhododermis*... p. 104

10. Thallus of very fine *unbranched* filaments attached singly to the substratum 11

Thallus of fine *branched* filaments, monosiphonous throughout; with or without a system of irregular delicate filaments clothing the cells of the main axes 12

Thallus of branched filaments, originally *monosiphonous* but becoming polysiphonous by longitudinal division of cells of main axes, or by cortication in various ways so that ultimate branches or apices of main axes alone show the monosiphonous condition 23

Thallus of various forms, cylindrical, compressed or laminate but *not obviously monosiphonous* 34

11. Filaments monosiphonous ... ... *Erythrotrichia* ...p. 76

Filaments becoming polysiphonous but with cell groups arranged in bands of greater width than length ... ... *Bangia* ...p. 76

12. Cylindrical branched algae, very gelatinous and worm-like; built up of numerous monosiphonous filaments, longitudinally and radially arranged, more or less separable under pressure 36

Filamentous algae, not gelatinous or vermiform, with branches all opposite or whorled, or some alternate and some opposite 13

Filamentous algae, not gelatinous or vermiform, with branches alternate 19

13. Branches whorled 14

Branches opposite or occasionally in threes, or main branches alternate and ultimate branches opposite 16

14. Thallus small, delicate, pinnately divided ; main branches in whorls, sometimes in threes ; tetraspores cruciately divided ... *Antithamnion* ...p. 98

Plants 2-6 inches long, densely covered by branches in whorls or coming off irregularly all round the main axes 15

15. Cells of main filaments very large and uncorticated ; whorls of branches overlapping one another giving a bottle-brush effect ... ... *Halurus* ...p. 94

Whorls of branches separated from one another, showing main filament in between ; cells of main branches may be corticated *Spondylothamnion* ...p. 93

16. Small plants forming dense cushions or tufts of filaments, quarter to three-eighths inch long ; main branches alternate, ultimate branches opposite; tetraspores singly or in groups on lateral branches 17

Plants with definitely pinnate or whorled fronds 18

17. Cells of the filament showing here and there small interpolated colourless cells ... ... *Trailliella* ...p. 93

Cells of the filament without small colourless cells *Spermothamnion* ...p. 93

18. Delicate pinnately divided plants, less than three-quarters inch long, with tetrahedrally divided tetraspores on the ends of the pinnules ... ... *Ptilothamnion* ...p. 93

Pinnately divided or whorled plants, three-quarters to two inches long ; cruciately divided tetraspores as lateral appendages, stalked or sessile ... ... *Antithamnion* ...p. 98

19. Plants in small tufts or forming a dense fluffy covering to other algae or to the substratum (especially where a thin coating of sand covers the rock) ; plants half-inch long, or less 20

Plants three-quarters to 5 inches in length, forming tufts of branched filaments 21

20. One chromatophore in each cell, usually with a conspicuous pyrenoid ; monospores or (occasionally) cruciately divided tetraspores ... ... *Acrochaetium* ...p. 77

Several ribbon-shaped or spirally twisted chromatophores in each cell ; cruciately divided tetraspores *Rhodochorton* ...p. 95

21. Plants of conspicuously bright red colour, usually dichotomously branched and uncorticated, growing in stiff tufts, 2-6 inches long; reproductive organs in groups on special branches with short lateral pedicels and surrounded by a whorl of claw-like investing filaments; "cells" of the filaments enormously large... ... ... *Griffithsia* ...p. 94

Plant not as above 22

22. Plant 2-4 inches long, uncorticated except for a few rhizoidal filaments at the base of the main axes; large-celled, bearing ovoid monospores (or occasionally tetraspores) on the inner side of clustered branches; cystocarps invested by a whorl of single-celled filaments of large size ... ... *Monospora* ...p. 94

Plant with lateral branches whose proximal half is bare, but pinnately branched in the distal half; tetraspore mother-cells divided up by many radiating walls into a large number of polyspores; cystocarps terminal, surrounded by a whorl of one-celled branches ... ... *Pleonosporium* ...p. 94

Bright red plants, 2-4 inches long, much branched, each branch ending in a hair; tetraspores as lateral branches; but plant more commonly reproduces by chains of ovoid "seirospores," formed by transformation of the cells of terminal dichotomous or trichotomous branches ... ... *Seirospora* ...p. 97

Plant showing branching in one plane; bi-, tri- or quadri-pinnate, *with terminal tetraspores* on ultimate pinnules ... *Compsothamnion* ...p. 97

Much-branched plant with tetrahedrally divided tetraspores arising laterally; cystocarps usually in pairs, one on each side of the filament; cystocarps without investing filaments ... *Callithamnion* ...p. 95

23. Plant fundamentally of a *polysiphonous* axis with a central row of cells, each of which is surrounded by a varying number of pericentral cells of equal length; the polysiphonous axis may be hidden by a mantle of small corticating cells 24

Plant cylindrical, or dorsiventrally flattened, but fundamentally of a *monosiphonous* axis, partially covered by bands of small cells, or completely enveloped in a sheath of irregular corticating cells 28

24. Plant wth polysiphonous main axes but with persistent monosiphonous lateral branches 25

Plant polysiphonous throughout except for terminal groups of colourless hairs sometimes shed at maturity 27

25. Thallus flattened in one plane ... ... *Heterosiphonia* ...p. 93

Thallus branched in all planes 26

26. Ultimate branches in the form of slender colourless hairs with elongated cells; tetraspores singly in rows in the distal portion of branches ... ... *Brongniartella* ...p. 92

Ultimate branches coloured, stout, curved and pointed; tetraspores arranged in whorls, 5-8 in a whorl on special cylindrical branches with slender pedicels ... ... *Dasya* ...p. 92

27. Thallus branched in one plane forming fern-like fronds bi- or tri-pinnately divided; or corticated entirely with the exception of youngest branches, but with polysiphonous main axis discernible ... ... *Pterosiphonia* ...p. 92

Thallus cylindrical, unbranched, polysiphonous but uncorticated except for main axis; frequently beset with groups of colourless hairs at the branch apices ... *Polysiphonia* ...p. 90

Thallus cylindrical with a group of 5-6 central siphons well covered by a corticating layer several cells thick; *branches attenuated at point of insertion;* tetraspores embedded in cortex of ultimate branches; antheridia terminal in groups; cystocarps lateral ... ... *Chondria* ...p. 89
(See Note 16, p. 116)

Thallus cylindrical with a few rows of elongated cells in the centre, surrounded by a cortical mantle several cells in thickness (longitudinal section does not show central and pericentral cells of uniform length with their crosswalls in the same planes) ... ... *Rhodomela* ...p. 88
(See Note 17, p. 116)

28. Thallus cylindrical 31

Thallus dorsiventrally flattened 29

29. Thallus tough, irregularly pinnately divided, dark in colour or multi-coloured; branches of varying width *Gelidium* ...p. 80

Thallus rigid, usually stiff enough to maintain its shape when held out of the water; regularly pinnate with alternate long and short branches corticated to their tips ... *Ptilota* ...p. 97

Thallus soft, clinging to the fingers; branches of unequal length, but not regularly long and short; youngest branches monosiphonous ... ... *Plumaria* ...p. 97

Whole plant covered with short spine-like opposite branches lying in one plane; cystocarps terminal on short lateral branches ... ... *Bonnemaisonia* ...p. 88

30. Plant cylindrical, branched in one or in all planes, but main axes not flattened 31

Whole plant covered with short spine-like opposite branches lying in one plane; cystocarps terminal on short lateral branches ... ... *Bonnemaisonia* ...p. 88

31. Axial row of cells clearly discernible, either showing through the cortex or giving a "beaded" articulated outline to the plant 32

Axial row of cells not clearly shown except in very young branches 33

32. Plant cylindrical, branched; central siphon of very large barrel-shaped or spherical cells, covered only by ring-like bands of small cells or completely corticated, in which case the swollen axial cells give an articulated outline to the plant; tetraspores in whorls, arising in the cortex *Ceramium* ...p. 98

Plant cylindrical and branched; with a definite axial row of large cells, but the outline of the plant is not "beaded"; axial row of cells covered by a double cortex of larger cells within and very small ones on the periphery; tetraspores not in whorls ... ... *Microcladia* ...p. 100

Thallus at first with single axial row giving off whorls of much-forked branches; central axis reinforced later by downwardly-growing filaments. (Distinguishable from *Nemalion* by presence of *whorled* lateral branches) ... *Dudresnaya* ...p. 100

33. Plant cylindrical, branched; central siphon not clearly shown; transverse section shows group of 5-8 large cells surrounded by a mantle of smaller cells; plant closely beset with short branches attenuated at both ends ... *Naccaria* ...p. 79

Plant cylindrical, branched; central siphon not clearly shown; transverse section may show large cell in centre surrounded by large number of others which decrease in size towards the periphery; cystocarps in flask-shaped receptacles, terminal on short branches; tetraspores in one or two rows, half immersed in special branches, attenuated at both ends *Rhodomela* ...p. 88

Plant profusely branched, traversed by single axial thread from which arise whorls of filaments uniting to form a thick cortex of which the outer layer is composed of radially arranged branches of equal length, closely adherent to one another but separable under pressure; plant may be hollow when old ... ... *Gloeosiphonia* ...p. 100

34. Thallus a shapeless brown-purple membrane, without any rigidity; cells in packets embedded in a colourless matrix; plant has the texture of a deflated indiarubber balloon... *Porphyra* ...p. 76

Plant a minute parasite entirely buried in the tissues of the host and causing swellings or pustules on its surface, in which the parasite develops reproductive organs 35

Very gelatinous worm-like algae, built up of longitudinally running filaments from which arise radially arranged cortical filaments held together by mucilaginous material 36

Algae of various types of organisation 39

35. Parasitic on *Rhodomela subfusca* ... ... *Harveyella* ...p. 79

Parasitic on *Polysiphonia fastigiata* ... *Choreocolax* ...p. 79

Parasitic on *Phyllophora Brodiaei or Gymnogongrus Griffithsiae* *Actinococcus* ...p. 82

Parasitic on *Ahnfeltia plicata* ... ... *Sterrocolax* ...p. 82

36. Thallus at maturity hollow, with inner cortex of longitudinally running filaments, giving off closely set, radially arranged peripheral branches; when young central part traversed by a single axial chain of cells ... ... *Gloeosiphonia* ...p. 100

Thallus never hollow; medulla of longitudinal filaments or large cells, but without a distinct axial row... 37

Thallus at first with a single axial row giving off whorls of much-forked lateral branches; central axis reinforced later by downwardly-growing filaments (distinguishable from *Nemalion* by presence of *whorled* lateral branches) *Dudresnaya* ...p. 100

37. Thallus simple or more or less dichotomously branched; cortex of radiating filaments, separable under pressure and not forming a pseudo-epidermis; cystocarps terminal on short branches not surrounded by special investing filaments ... *Nemalion* ...p. 78

Thallus dichotomously branched, cylindrical, with a surface layer of colourless cells united into a pseudo-epidermis; embedded cystocarps opening by a pore to the exterior ... *Scinaia* ...p. 79

Thallus with distinct main axis and lateral branches; cystocarps surrounded by special investing filaments 38

38. Medulla formed of a bundle of attenuated filaments giving off a cortical system of radial branches *Helminthocladia* ...p. 78

Medulla formed of large cells elongated in the direction of the axis, interwoven by narrow filaments, and covered by groups of radiating branches which, in youth, end in colourless hairs... *Helminthora* ...p. 78

39. Plant cylindrical, sometimes slightly flattened; with a smooth outline or articulated into separate segments but not expanded distally into narrow blades 50

Plant with a stem-portion passing gradually into a distally expanded blade 58

Thallus consisting almost entirely of an expanded lamina, sometimes with veins but without a definite midrib; with or without a short inconspicuous stem 45

Thallus with stem and leaf-like appendages; or with distinct midrib and lateral laminae; vegetative apex marked by definite apical cell 44

Thallus expanded into a much branched, *fern-like* frond with narrow segments not more than ½ inch in breadth 40

40. Branches opposite; thallus tri- or quadri-pinnate with very narrow linear segments; a single axial row of cells discernible in the ultimate branches... 41

Branches alternate (opposite or whorled in *Laurencia obtusa*) ... 42

41. Thallus rigid, usually stiff enough to retain its shape when held out of the water; regularly quadripinnate, with alternate long and short branches corticated to their tips... *Ptilota* ...p. 97

Thallus soft, clinging to the fingers when lifted out of the water ; branches of unequal length but not regularly long and short... *Plumaria* ...p. 97

Thallus covered with short spine-like, opposite branches in one plane ; cystocarps terminal on short lateral branches ... *Bonnemaisonia* ...p. 88

42. Thallus with a prominent midrib and a narrow labial wing on each side, markedly reduced in the axils of branches ... ... *Delesseria alata* ...p. 87

Thallus not conspicuously differentiated into midrib and lateral wings 43

43. Small plants with fronds 1-2 inches long, dark in colour ; longitudinal section of younger parts of the fronds shows a central group of elongated cells ... ... *Gelidium* ...p. 80

Thallus of solid texture, dark red in colour, quarter to half an inch in width ; several sharply marked teeth on each pinnule ... ... *Odonthalia* ...p. 89

Thallus with narrow segments, the ultimate ones arising unilaterally like the teeth on a comb ; zonately divided tetraspores in special marginal clusters of branches *Plocamium* ...p. 86

Narrow ribbon-like, much divided thallus, beset with numerous short, lateral appendages sometimes distended into globular swellings ... ... *Sphaerococcus* ...p. 83

Substantial fronds with blunt-ended lateral branches but not conspicuously narrow insertions ; transverse section circular or ovoid in outline ... ... *Laurencia* ...p. 89

44. Stem beset with numerous irregularly lobed leaf-like appendages, each with conspicuous veinings ; main stem and margins of the frond frequently covered with small irregular emergences bearing reproductive organs ... ... *Phycodrys* ...p. 87

Stem short, stout and creeping, bearing conspicuous upright pointed " leaves," 2-5 inches long *Delesseria sanguinea* ...p. 87

Thallus ribbon-like with a narrow lamina on each side of the midrib ... ... *Delesseria alata* ...p. 87

Thallus narrow with secondary and tertiary branches springing from the midribs *Delesseria hypoglossum* or *D. ruscifolia* ...p. 88

45. Thallus $\frac{1}{2}$ to $1\frac{1}{2}$ inches long, consisting of a flattened ovoid frond from the margins of which spring a few (6-12) similar branches *Lomentaria rosea* ...p. 85

Plant of extreme leatheriness of texture ; bright red in colour, forming single (or few) spoon-shaped blades, 2-6 inches in diameter attenuated towards the base ... *Dilsea* ...p. 100

Thallus of tough and almost opaque fronds, completely laminate, usually without a stem-like portion, variously lobed and frilled, without veins 46

Thallus expanded into a delicate, usually a transparent membrane ; with or without veins ; variously divided into lobes or ribbon-like segments ; sometimes frilled at the margins... 47

46\. Plant rose-coloured, almost transparent; transverse section shows four rows of cells only, of which the two innermost are rectangular in outline and very large; superficial tissue a single layer of very small cells ... ... *Halarachnion* ...p. 101

Plant dark red in colour, at least at the base, sometimes freely proliferating from the margin; transverse section shows central tissue of large rounded colourless cells; tetraspores cruciately divided ... ... *Rhodymenia* ...p. 84

Large membraneous algae of stout texture, usually undivided though sometimes lobed; central tissues of longitudinally elongated and interwoven filaments covered by cortical layers of small cells ... ... *Callymenia* ...p. 82

Thallus bright red, opaque, broad, dichotomously divided, spreading out fan-wise; frequently with proliferations from the margins ... ... *Callophyllis* ...p. 82

47\. Thallus extremely delicate in texture; the greater part of it one cell only in thickness; variously lobed and divided; sometimes with short irregular veins; apical cell not distinct; tetraspores tetrahedrally divided; cystocarps scattered over the frond ... ... *Nitophyllum* ...p. 86

Thallus several cell layers in thickness 48

48\. Large membraneous algae of stout texture, undivided or irregularly lobed 49

Thallus bright-red, opaque, broad, dichotomously divided, spreading out fan-wise; frequently with proliferations from the margins; cystocarps and tetraspores scattered over the thallus or localised on the proliferations *Callophyllis* ...p. 82

Thallus very delicate in texture, pale in colour, very finely divided into narrow ribbon-like segments, quarter inch in diameter, often toothed; cystocarps large and prominent on the margins of the fronds; tetraspores relegated to the tips of the ultimate branches; longitudinal section shows a medulla built up of dichotomously branched rows of large cells ... *Euthora* ...p. 83

Thallus of delicate texture divided into lobes that are frequently dichotomous; growing in almost spherical masses 2-6 inches in diameter; zonate tetraspores mostly on the tips of the fronds; cystocarps scattered along the margins; longitudinal section of the medulla shows a central filament of elongated cells giving off alternate branches ... *Rhodophyllis* ...p. 83

Thallus with an elongated lanceolate blade giving off irregularly (sometimes pinnately) marginal tongue-like branches ... *Calliblepharis* ...p. 84

49\. Central tissue of longitudinally elongated and interwoven filaments covered by cortical layers of small cells *Callymenia* ...p. 82

Central tissues of large rounded colourless cells clearly visible through the superficial layers of small cells *Rhodymenia* ...p. 84

50. Thallus hollow, or stem solid and branches hollow 51
Thallus solid throughout 54

51. Thallus, at least the main branches of it, not obviously constricted into articulated joints; branched in one or in all planes 52
Thallus, both main stem and branches, definitely constricted into articulated joints 53

52. Thallus branched sparingly at the base, forming clumps of tubular, irregular and sometimes twisted branches, slightly flattened; 3-12 inches in length by $\frac{1}{4}$ to $\frac{1}{2}$ an inch in width; dark purple-red or brownish in colour; built up of longitudinally running threads giving off short peripheral branches and covered by a layer or two of very small branches ... ... *Dumontia* ...p. 100
Thallus 2-6 inches long, much branched; finely divided, usually in one plane only, but sometimes in all planes; bi- or tri-pinnate; each pinnule an elongated club-shaped branch, attenuated at both ends ... *Lomentaria clavellosa* ...p. 85
Thallus $\frac{1}{2}$ to $1\frac{1}{2}$ inches long, consisting of a flattened ovoid frond, from the margins of which spring a small number (6-12) of similar branches ... ... *Lomentaria rosea* ...p. 85
Main stem cylindrical, closely beset at or near the apex with distended ovoid branches, on which or in which reproductive organs may occur ... ... *Chylocladia ovatus* ...p. 86

53. Very small plant, about $\frac{3}{4}$ inch in height; blackish, found in crevices of rock in upper half of littoral zone; thallus not completely hollow but traversed by a wide-meshed network of interlacing filaments; tetraspores zonately divided ... *Catenella* ...p. 83
Plant 2-4 inches long, clearly and definitely articulated into bead-like joints, but branched more or less in one plane, forming fan-shaped fronds; articulations of main stem about $\frac{1}{4}$ inch in length ... ... *Lomentaria articulata* ...p. 85
Plant 5-12 inches long of pyramidal outline; branches arising in whorls of 3-6, secondary and tertiary branches similar; articulations of main stem $\frac{1}{2}$ to $\frac{3}{4}$ inch in length ... ... *Chylocladia kaliformis* ...p. 85
Plant 1-4 inches long, forming a dense tuft of spreading branches, whose segments, though definitely articulated, are not conspicuously swollen in their middle region *Champia* ...p. 85

54. Thallus less than 1 inch long, articulated into bead-like joints; black or dark purple in colour ... ... *Catenella* ...p. 83
Thallus cylindrical or slightly compressed but not articulated into bead-like joints 55

55. Thallus with sturdy cylindrical stems, $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter, 3-6 inches long, repeatedly forked; terminal branches slightly swollen, reaching a uniform height and giving a very regular appearance to the plant 56

Thallus irregularly branched, of extreme wiriness; almost black in colour ... ... *Ahnfeltia* ...p. 82

Plant not rigid, cylindrical, purple-red, much branched, forming bushy tufts 4-18 inches long 57

56. Plant attached to the substratum by *branched finger-like "rootlets"*; reproductive rogans in swollen terminal branches; tetraspores zonately divided *Furcellaria* ...p. 101

Plant attached by *compact basal disc*; reproductive organs in wart-like swellings developed laterally on the thallus ... *Polyides* ...p. 101

Thallus dichotomously branched in one plane, forming compact tufts 2-4 inches high; tetraspores cruciately divided ... *Gymnogongrus* ...p. 81

57. Much branched plant with medulla composed of longitudinally elongated filaments; tetraspores *zonately* divided ... *Cystoclonium* ...p. 82

Plant with medulla of large colourless cells not elongated as hyphae; tetraspores *cruciately* divided ... *Gracilaria* ...p. 84

58. Thallus more or less pinnately divided ... *Laurencia* ...p. 89

Plant of extreme leatheriness of texture; bright red in colour, forming single (or few) spoon-shaped blades, 2-6 inches in diameter, attenuated towards the base ... *Dilsea* ...p. 100

Thallus of tough texture, dark in colour; irregularly pinnate, or lanceolate with strap-shaped or filiform emergences arising on the margins 59

Thallus more or less perfectly dichotomous 60

59. Small plants with fronds 1-3 inches long, dark in colour; younger parts of the plant in section show *a central group of elongated* cells ... ... *Gelidium* ...p. 80

Thallus consisting of a stalked blade 2-7 inches long with a series of filiform appendages half to three-quarter inch long arising from the margin; tetraspores zonately divided ... *Calliblepharis* ...p. 84

60. Thallus with medulla of interwoven threads, giving off obliquely ascending filaments, from which arises a cortex of radially arranged filaments; cruciately divided tetraspores *not in nemathecia* 61

Thallus with a medulla of large, loosely packed cells and small-celled cortex; *tetraspores in nemathecia* *Phyllophora* ...p. 81

61. Thallus dichotomously branched, very variable in width and in texture, spreading out into fan-like expansions; cystocarps embedded in the frond ... ... *Chondrus* ...p. 80

Thallus not dichotomously branched; tips of the fronds expanded somewhat suddenly into more or less triangular blades; cystocarps in special papillate emergences arising from the distal expanded portions of the thallus, more numerous on one side than the other ... *Gigartina* ...p. 81

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EXPLANATION OF PLATES

Plate I.

View of the limestone terraces, Port St. Mary, looking south. Saucer shaped " coralline " pools in foreground.

Plate II.

Photograph of a pool taken from above. The limestone surface shews embedded fossils, and the vegetation consists of discs of *Ralfsia verrucosa* (dark, with faint light lines) and small plants of *Lithothamnion Lenormandi* (white).

Plate III.

Inter-pool vegetation about mid-tide zone on the limestone terraces, Port St. Mary. The rock surface is encrusted with *Lithothamnion Lenormandi* which is beset with stunted plants of *Corallina officinalis*. The upper storey of vegetation consists of *Laurencia hybrida*.

Plate IV.

A pool at low tide zone, Pooyllvaaish, shewing *Laminaria digitata* and *Fucus serratus* with a scattered growth of *Ascophyllum nodosum* on the higher rocks.

Plate V.

Inter-pool vegetation on the limestone terraces, Port St. Mary. Colonies of *Himanthalia lorea* in all stages of growth are shewn. The undergrowth consists of a basal layer of *Lithothamnion Lenormandi* bearing distorted plants of *Corallina officinalis*, both of which are covered by *Laurencia hybrida*.

Plate VI.

A pool from just above mid-tide zone on the limestone terraces, Port St. Mary, shewing the condition of the pool in April. *Lithothamnion Lenormandi* makes a continuous carpet over the rock surface. *Corallina officinalis* fringes the edge and a mixed vegetation in young stages of development crowns conspicuous " limpet-islands."

Plate VII.

A pool from mid-tide zone on the limestone terraces, Port St. Mary. The floor of the pool is completely covered with *Lithothamnion Lenormandi* and the margin shews *Corallina officinalis*. The photograph was taken in April when representatives of other genera (*Ulva*, *Scytosiphon*) were just making their appearance as epiphytes on the *Corallina*.

Plate VIII.

Fig. 1. Part of a filament of *Ectocarpus tomentosoides* shewing uniseriate plurilocular sporangia. $\times$ 400.

Fig. 2. Plurilocular sporangium and part of the filament shewing cell-organisation in *Ectocarpus tomentosoides*. $\times$ 800.

Fig. 3. Cell-organisation of *Ectocarpus confervoides*. $\times$ 1500.

Fig. 4. Filaments shewing plurilocular sporangia and method of branching in *Ectocarpus confervoides*. × 240.

Fig. 5. Part of a plant of *Ectocarpus fasciculatus* var. *refracta* with plurilocular sporangia. × 240.

Fig. 6. Cell-organisation of *Ectocarpus fasciculatus*. × 2000.

Plate IX.

Fig. 7. A section of a young plant of *Ulonema rhizophorum* from the thallus of *Rhodymenia palmata*. × 800.

Fig. 8. Cell-organisation of *Ectocarpus simplex*. × 1500.

Fig. 9. The distal end of a filament of *Ectocarpus simplex* shewing attenuation when compared with Figs. 11 and 12. × 240.

Fig. 10. Surface view of margin of disc of young plant of *Ulonema rhizophorum*. × 800.

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Fig. 12. *Ectocarpus simplex* with unilocular sporangia. × 240.

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Plate X.

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Fig. 15. Section from the thallus of *Himanthalia lorea* shewing the attachment of a young plant of *Ectocarpus velutinus* with unilocular sporangia. × 300.

Fig. 16. Part of a filament of *Ectocarpus tomentosus* with plurilocular sporangia. × 480.

Fig. 17. Part of a plant of *Hecatonema maculans* from the fronds of *Corallina officinalis*. Note the intrusion of vegetative filaments into empty plurilocular sporangia. × 400.

Fig. 18. Part of the filament of *Isthmoplea sphaerophora* with unilocular sporangia. × 240.

Plate XI

Fig. 19. Filaments of *Ectocarpus luteolus* with plurilocular sporangia, from surface of stem of an old frond of *Fucus serratus*. × 240.

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Fig. 21. Cell-organisation of *Myriotrichia filiformis*. × 1000.

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Fig. 23. Part of a plant of *Ectocarpus fasciculatus* forma *typica* with unilocular sporangia. × 240.

Fig. 24. A section through the thallus of *Fucus serratus* shewing the basal part of a plant of *Ectocarpus luteolus*. × 240.

Fig. 25. Part of a plant of *Ectocarpus fasciculatus* forma *typica* with plurilocular sporangia. × 240.

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Fig. 27. Unilocular sporangia and assimilatory filament of *Myrionema saxicola*. × 460.

Fig. 28. A section through the thallus of *Chylocladia kaliformis*, shewing a plant of *Streblonema Zanardinii* creeping on the surface. × 240.

Fig. 29. Part of the vegetative thallus of *Myrionema saxicola* scraped from a rock surface. × 240.

Fig. 30. Part of a plant of *Ectocarpus ovatus* var. *arachnoideus* with unilocular and plurilocular sporangia. × 240.

Fig. 31. *Ascocyclus saccharinae* with assimilatory filaments and plurilocular sporangium. × 1500.

Fig. 32. A filament of *Streblonema Zanardinii* shewing plurilocular sporangia and mucilage hairs, from the tissue of *Chylocladia kaliformis*. × 460.

Plate XIII.

Fig. 33. Plurilocular sporangia of *Ectocarpus parasiticus* from the surface of *Cystoclonium purpureum*. × 460.

Fig. 34. Surface view of sterile plant of *Acrochaetium endozoicum* in *Alcyonidium hirsutum*. × 400.

Fig. 35. Basal part of *Leptonema fasciculatum* with unilocular sporangia. × 400.

Fig. 36. Distal part of filament of *Leptonema fasciculatum* with plurilocular sporangia. × 400.

Fig. 37. Filament of *Ectocarpus parasiticus* creeping in the tissue of *Cystoclonium purpureum*. × 240.

Fig. 38. Transverse section of the thallus of *Stictyosiphon tortilis*, shewing superficial cells transformed into plurilocular sporangia. × 240.

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Fig. 40. *Acrochaetium endozoicum* within the body of *Alcyonidium hirsutum*. Emergent filaments producing monospores. × 400.

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Fig. 41. Single cell from a filament of *Urospora collabens* shewing typical globular form. × 460.

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Fig. 43. Filament cell with accompanying "gland" cell of *Trailliella intricata*. × 460.

Fig. 44. Filaments of *Trailliella intricata* shewing method of branching and interpolated "gland" cells. × 80.

Fig. 45. *Colaconema reticulata* (?) within the cell wall of Cladophora sp. × 800.

Fig. 46. Cells of *Urospora bangioides* in process of gamete-formation. × 240.

Fig. 47. Cells of *Urospora isogona* in process of zoospore-formation. × 400.

Plate XV.

Fig. 48. Unilocular sporangium of *Codiolum gregarium*. × 400.

Fig. 49. Surface cells of *Enteromorpha micrococca*. × 120.

Fig. 50. Section through tubular frond of *Enteromorpha micrococca*, shewing very thick mucilaginous inner wall of the tube. × 120.

Fig. 51. *Endoderma Flustrae* var. *Phillipsii* with zoosporangia, in the body of *Alcyonidium hirsutum*. × 360.

Fig. 52. *Enteromorpha micrococca*. × 10.

Fig. 53. Single plant of *Codiolum gregarium* in a vegetative condition, with conspicuous pyrenoids. × 240.

Fig. 54. *Endoderma Flustrae* with zoosporangia, within the body of *Flustra*. × 360.

Fig. 55. Lateral view of a filament of *Percursaria percursa*, shewing parietal chromatophores. × 460.

Fig. 56. Surface view of a filament of *Percursaria percursa* with conspicuous pyrenoids. × 460.

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Fig. 57. Detail of the branching of *Callithamnion scopulorum*. × 20.

Fig. 58. *Choreocolax Polysiphoniae* on *Polysiphonia fastigiata*. × 120.

Fig. 59. Plants of *Prasiola stipitata*. Nat. size.

Fig. 60. Part of a plant of *Callithamnion Dudresnayi* with tetraspores. × 40.

Fig. 61. Surface of *Aglaozonia reptans*, scraped from stones. × 20.

Plate XVII.

Fig. 62. Part of a frond shewing the habit and branching of *Callithamnion scopulorum*. × 2.

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Fig. 64. *Callithamnion polyspermum*. × 2.

Fig. 65. *Callithamnion Dudresnayi*. × 2.

Fig. 66. Part of a frond of *Antithamnion cruciatum*. × 50.

Fig. 67. Part of a *Callithamnion* whose habit is intergrade between *C. Hookeri* and *C. polyspermum*. × 2.

Fig. 68. Part of a plant of *Callithamnion arbuscula*. × 2.

PLATE XVIII.

Figs. 69, 70. Plants shewing intergrade condition between *Callithamnion Hookeri* and *C. polyspermum*. × 2.

Fig. 71. Young plants of *Nitophyllum uncinatum*. Nat. size.

Fig. 72. Part of a plant of *Pleonosporium Borreri*. × 2.

Fig. 73. Part of a plant of *Callithamnion corymbosum*. × 2.

Fig. 74. A young plant of *Callithamnion brachiatum*. × 2.

PLATE XIX.

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Fig. 77. Part of a filament of *Rhizoclonium Kerneri*. × 240.

Fig. 78. *Streblonema infestians*. × 360.

Fig. 79. *Ectocarpus brevis*. × 480.

Fig. 80. *Ectocarpus fasciculatus* var. *Draparnaldioides*. × 240.

	Tilopteris Mertensii.	*Leathesia difformis*		
PROCARPS and CYSTOCARPS	*Rhodophyllis bifida* *Odonthalia dentata* *Callithamnion roseum* *Corallina officinalis* *Plumaria elegans* *Callithamnion tetragonum* *Furcellaria fastigiata*	*Ceramium rubrum* *Ceramium diaphanum* *Cystoclonium purpureum* *Calliblepharis lanceolata* *Callophyllis laciniata* *Euthora cristata* *Plocamium coccineum* *Laurencia obtusa* *Catenella repens* *Furcellaria fastigiata* *Corallina squamata* *Lithothamnion Lenormandi* *Polysiphonia spinulosa* var. *major* *Polysiphonia elongata* *Polysiphonia fastigiata* *Polysiphonia nigra* *Scinaia furcellata* *Callithamnion roseum*	*Gracilaria confervoides* *Halarachnion ligulatum*	
	Rhodomela subfusca	*Nemalion multifidum* *Chondria dasyphylla*	*Polysiphonia fastigiata* *Polysiphonia Brodiaei*	*Chondrus crispus* *Rhodomela subfusca*

TABLE OF REPRODUCTION

	SPRING (March, April, May)	SUMMER (June, July, August).	AUTUMN (Sept., Oct., Nov.).	WINTER (Dec., Jan., Feb.).
PROPAGULES	Sphacelaria cirrhosa	Sphacelaria cirrhosa	Sphacelaria cirrhosa	Sphacelaria cirrhosa Sphacelaria fusca
ZOOSPORANGIA	Enteromorpha compressa Enteromorpha clathrata Enteromorpha micrococca Ulva latissima Monostroma Wittrockii Monostroma Grevillei Endoderma Wittrockii Urospora isogona Prasiola stipitata Percursaria percursa Chaetomorpha melagonium Rhizoclonium riparium Laminaria saccharina Laminaria digitata Laminaria Cloustoni Alaria esculenta Aglaozonia reptans Saccorhiza polyschides	Monostroma Wittrockii Monostroma Grevillei Codiolum Petrocelidis Codiolum gregarium Enteromorpha spp. Ulva latissima (abundant) Endoderma viride Prasiola stipitata Percursaria percursa Ulothrix spp. Laminaria saccharina Laminaria digitata Laminaria Cloustoni Alaria esculenta Saccorhiza polyschides Aglaozonia reptans	Urospora isogona Percursaria percursa Ulva latissima Prasiola stipitata Enteromorpha compressa Enteromorpha clathrata Laminaria saccharina Laminaria Cloustoni Alaria esculenta Saccorhiza polyschides	Enteromorpha compressa Urospora bangioides Ulva latissima Prasiola stipitata Urospora isogona Laminaria saccharina Laminaria Cloustoni Alaria esculenta Saccorhiza polyschides
GAMETANGIA	Urospora isogona Urospora bangioides Cladophora rupestris Cladophora arcta Cladophora pellucida Cladophora utriculosa Cladophora fracta var. flavescens Codium tomentosum Fucus spiralis Ascophyllum nodosum Himanthalia lorea Dictyota dichotoma	Cladophora spp Codium mucronatum Bryopsis plumosa Bryopsis hypnoides Fucus spiralis Fucus vesiculosus Pelvetia canaliculata Himanthalia lorea Halidrys siliquosa Dictyota dichotoma Cutleria multifida Ascophyllum nodosum	Fucus spiralis Fucus ceranoides Fucus serratus Cutleria multifida	Codium tomentosum Fucus serratus Ascophyllum nodosum Fucus ceranoides
UNILOCULAR SPORANGIA	Ectocarpus siliculosus Ectocarpus tomentosus Ectocarpus Hincksiae Ectocarpus granulosus (rare) Ectocarpus simplex Ectocarpus confervoides Ectocarpus confervoides var. penicilliformis Ectocarpus fasciculatus Ectocarpus fasciculatus var. refracta Ectocarpus fasciculatus var. draparnaldioides Pylaiella littoralis Punctaria plantaginea Punctaria latifolia Punctaria tenuissima Stictyosiphon tortilis Isthmoplea sphaerophora Elachista fucicola Elachista scutulata Cladostephus spongiosus Sphacelaria radicans Halopteris filicina Leptonema fasciculatum Phloeospora brachiata Asperococcus fistulosus Chaetopteris plumosa Chorda filum	Dictyosiphon foeniculaceus Litosiphon pusillus Phloeospora brachiata Punctaria plantaginea Punctaria tenuissima Punctaria latifolia Asperococcus bullosus Myriotrichia clavaeformis Myriotrichia filiformis Elachista fucicola Elachista scutulata Elachista flaccida Sphacelaria bipinnata Chaetopteris plumosa Halopteris filicina Ectocarpus velutinus Ectocarpus confervoides var. penicilliformis Ectocarpus fasciculatus Myriactis stellulata Myriactis pulvinata Myrionema strangulans Chordaria divaricata Chordaria flagelliformis Mesogloia vermiculata Castagnea virescens Leathesia difformis Striaria attenuata Sporochnus pedunculatus Chorda filum Ulonema rhizophorum Stilophora rhizodes	Asperococcus fistulosus Ectocarpus siliculosus Ectocarpus tomentosus Pylaiella littoralis Elachista fucicola Elachista scutulata Cladostephus spongiosus Chordaria flagelliformis Dictyosiphon foeniculaceus Ectocarpus confervoides Stypocaulon scoparium Sporochnus pedunculatus (Sept.)	Asperococcus fistulosus Pylaiella littoralis Elachista fucicola Cladostephus spongiosus Cladostephus verticillatus Ralfsia verrucosa Ectocarpus terminalis Ectocarpus ovatus var. arachnoideus Sphacelaria cirrhosa Sphacelaria cirrhosa var. fusca Lithoderma fatiscens Myrionema saxicola
PLURILOCULAR SPORANGIA	Punctaria plantaginea Punctaria latifolia Asperococcus fistulosus Ectocarpus granulosus Ectocarpus simplex Ectocarpus Hincksiae Ectocarpus parasiticus Ectocarpus fasciculatus Ectocarpus fasciculatus var. draparnaldioides Ectocarpus fasciculatus var. refracta Ectocarpus tomentosoides Ectocarpus microscopicus Ectocarpus confervoides var. penicilliformis Pylaiella littoralis Myrionema aecidioides Phyllitis fascia Myriotrichia clavaeformis Myriotrichia filiformis Leptonema fasciculatum Litosiphon filiformis Streblonema infestans Streblonema Zanardinii Tilopteris Mertensii	Litosiphon pusillus Litosiphon Laminariae Phloeospora brachiata Punctaria plantaginea Punctaria latifolia Scytosiphon lomentarius Asperococcus bullosus Streblonema fasciculatum Sphacelaria bipinnata Myrionema strangulans Isthmoplea sphaerophora Ectocarpus luteolus Ectocarpus brevis Ectocarpus tomentosoides Ectocarpus siliculosus Ectocarpus tomentosus Ectocarpus Hincksiae Ectocarpus granulosus Ectocarpus confervoides Ectocarpus confervoides var. penicilliformis Ectocarpus fasciculatus Ectocarpus fasciculatus var. draparnaldioides Myriactis stellulata Myriactis pulvinata Leathesia difformis Myriotrichia clavaeformis Myriotrichia filiformis Colpomenia sinuosa	Ectocarpus tomentosoides Ectocarpus velutinus (Sept.) Pylaiella littoralis Cladostephus spongiosus Castagnea virescens (Sept.) Asperococcus fistulosus (Sept.) Hecatonema maculans Leathesia difformis (Sept.)	Phyllitis fascia Scytosiphon lomentarius Asperococcus fistulosus Pylaiella littoralis Ralfsia verrucosa Lithoderma fatiscens Leptonema fasciculatum Ectocarpus siliculosus Ectocarpus tomentosoides Ectocarpus ovatus var. arachnoideus Microsiphar Polysiphoniae Ectocarpus terminalis Cladostephus spongiosus Cladostephus verticillatus Ascocyclus saccharinae
PARA-SPORANGIA	Plumaria elegans Ptilota plumosa			Plumaria elegans
TETRA-SPORANGIA or MONO-SPORANGIA	Erythrocladia subintegra (Mono) Acrochaetium virgatulum (Mono) Acrochaetium emergens Acrochaetium endozoicum (Mono) Colaconema reticulatum (Mono) Lomentaria clavellosa Chylocladia ovatus Delesseria alata Nitophyllum punctatum Rhodomela subfusca Polysiphonia Brodiaei Griffithsia flosculosa Ptilota plumosa Ceramium rubrum Ceramium acanthonotum Rhodochorton Rothii Phycodrys rubens Dumontia incrassata Porphyra umbilicalis Porphyra leucosticta Callophyllis laciniata Rhodophyllis bifida Lomentaria rosea Odonthalia dentata Furcellaria fastigiata Laurencia hybrida Polysiphonia urceolata Callithamnion Hookeri Callithamnion tetragonum Callithamnion Dudresnayi Callithamnion scopulorum Callithamnion byssoides Ceramium strictum Hildenbrandia prototypus Corallina officinalis Corallina rubens Pterosiphonia thuyoides Heterosiphonia plumosa Ahnfeltia plicata Dictyota dichotoma Tilopteris Mertensii (Mono)	Lomentaria clavellosa Lomentaria rosea Plocamium coccineum Nitophyllum ramosum Nitophyllum punctatum Chondria tenuissima Polysiphonia elongata Polysiphonia violacea Spondylothamnion multifidum Griffithsia corallinoides Griffithsia flosculosa Ceramium Deslongchampsii Ceramium echionotum Furcellaria fastigiata Rhodophyllis bifida Sphaerococcus coronopifolius Lithothamnion Lenormandi Corallina squamata Laurencia hybrida Laurencia pinnatifida Corallina rubens Monospora pedicellata (Mono) Polysiphonia fruticulosa Brongniartella byssoides Callithamnion roseum	Erythrotrichia carnea Lomentaria articulata Delesseria hypoglossum Delesseria ruscifolia Odonthalia dentata Polysiphonia fastigiata Polysiphonia Brodiaei Heterosiphonia plumosa Griffithsia flosculosa Ptilota plumosa Ceramium rubrum Callithamnion arbuscula Callithamnion brachiatum Gelidium spp. Rhodophyllis bifida Dasya arbuscula Furcellaria fastigiata Dilsea edulis Lithothamnion lichenoides Lithothamnion Lenormandi Plocamium coccineum Brongniartella byssoides Antithamnion cruciatum Antithamnion plumula Dictyopteris membranacea Dictyota dichotoma Dictyota dichotoma var. implexa	Porphyra linearis Gelidium spp Chondrus crispus Rhodymenia palmata Lomentaria articulata Delesseria sanguinea Delesseria alata Delesseria ruscifolia Delesseria hypoglossum Rhodomela subfusca (Feb.) Polysiphonia Brodiaei Polysiphonia urceolata Griffithsia flosculosa Rhodochorton Rothii Acrochaetium virgatulum Laurencia pinnatifida Callithamnion byssoides Callithamnion polyspermum Callithamnion Hookeri Callithamnion brachiatum Callithamnion tetragonum Callithamnion scopulorum Ceramium rubrum Hildenbrandia prototypus Corallina officinalis Rhododermis elegans Lithophyllum incrustans Dictyopteris membranacea
PROCARPS and CYSTOCARPS	Polysiphonia fastigiata Polysiphonia fruticulosa Polysiphonia urceolata Polysiphonia elongata Polysiphonia nigrescens Polysiphonia violacea Pterosiphonia thuyoides Gigartina stellata Phyllophora epiphylla Lomentaria articulata Plocamium coccineum Nitophyllum punctatum Rhodomela subfusca Laurencia hybrida Griffithsia flosculosa Callithamnion Hookeri Ceramium rubrum Dumontia filiformis Phycodrys rubens Delesseria alata Rhodophyllis bifida Odonthalia dentata Callithamnion roseum Corallina officinalis Plumaria elegans Callithamnion tetragonum Furcellaria fastigiata	Gigartina stellata Laurencia hybrida Dasya arbuscula Nemalion multifidum Chylocladia ovatus Chylocladia kaliformis Chylocladia kaliformis var. squarrosa Delesseria hypoglossum Bonnemaisonia asparagoides Rhodophyllis bifida Odonthalia dentata Sphaerococcus coronopifolius Phycodrys rubens Gracilaria confervoides Brongniartella byssoides Heterosiphonia plumosa Griffithsia corallinoides Ceramium rubrum Ceramium diaphanum Cystoclonium purpureum Calliblepharis lanceolata Callophyllis laciniata Euthora cristata Plocamium coccineum Laurencia obtusa Catenella repens Furcellaria fastigiata Corallina squamata Lithothamnion Lenormandi Polysiphonia spinulosa var. major Polysiphonia elongata Polysiphonia fastigiata Polysiphonia nigra Scinaia furcellata Callithamnion roseum	Gigartina stellata Cystoclonium purpureum Nitophyllum ramosum Phycodrys rubens Delesseria sanguinea Delesseria ruscifolia Polysiphonia spinulosa Polysiphonia urceolata Polysiphonia Brodiaei Heterosiphonia plumosa Ptilota plumosa Callithamnion arbuscula Callithamnion brachiatum Lithothamnion Lenormandi Polysiphonia fastigiata Brongniartella byssoides (Sept.) Antithamnion plumula Rhodophyllis bifida Ceramium botryocarpum Gracilaria confervoides Halarachnion ligulatum	Chondrus Crispus Gigartina stellata Delesseria alata Delesseria sanguinea Laurencia pinnatifida Polysiphonia fastigiata Callithamnion Hookeri Callithamnion tetragonum Callithamnion brachiatum Callithamnion arbuscula Gelidium latifolium Rhodophyllis bifida Callophyllis laciniata Rhodomela subfusca Polysiphonia nigrescens Polysiphonia Brodiaei Laurencia pinnatifida Corallina officinalis
SPERMATANGIA	Rhodomela subfusca Rhodymenia palmata Lomentaria articulata Laurencia hybrida Griffithsia flosculosa Callithamnion Hookeri Callithamnion tetragonum Ceramium rubrum Dumontia incrassata Furcellaria fastigiata Cystoclonium purpureum Delesseria alata Polysiphonia urceolata Polysiphonia elongata Polysiphonia fastigiata Polysiphonia Brodiaei Polysiphonia nigrescens Polysiphonia violacea Polysiphonia fruticulosa Polysiphonia thuyoides	Nemalion multifidum Chondria dasyphylla Callithamnion roseum Furcellaria fastigiata Petrocelis cruenta Calliblepharis lanceolata Laurencia obtusa Dasya arbuscula Griffithsia corallinoides	Polysiphonia fastigiata Polysiphonia Brodiaei Polysiphonia urceolata Callithamnion tetragonum Callithamnion brachiatum Callithamnion tetragonum Halurus equisetifolius	Chondrus crispus Rhodomela subfusca Laurencia pinnatifida Laurencia hybrida Polysiphonia Brodiaei Griffithsia flosculosa Callithamnion Hookeri Callithamnion arbuscula Callithamnion tetragonum Callithamnion brachiatum Ceramium rubrum Lomentaria articulata Ceramium flabelligerum

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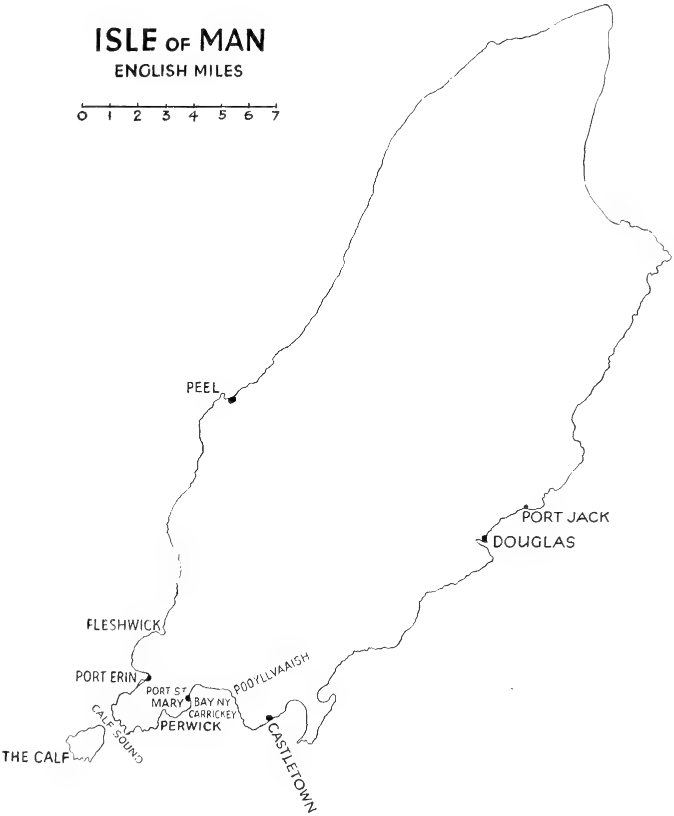
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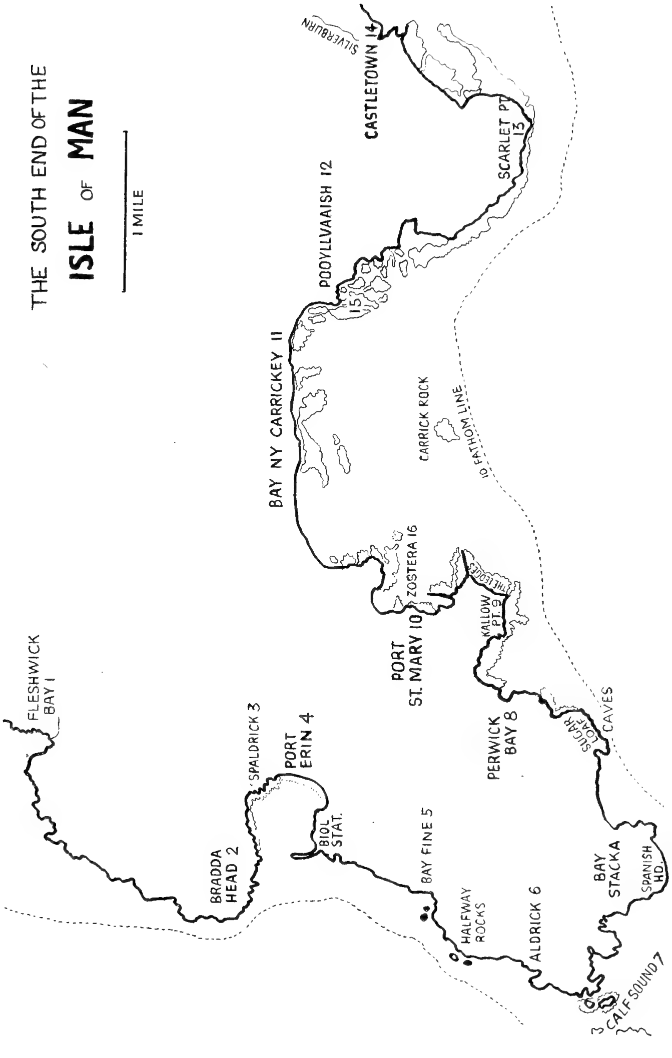
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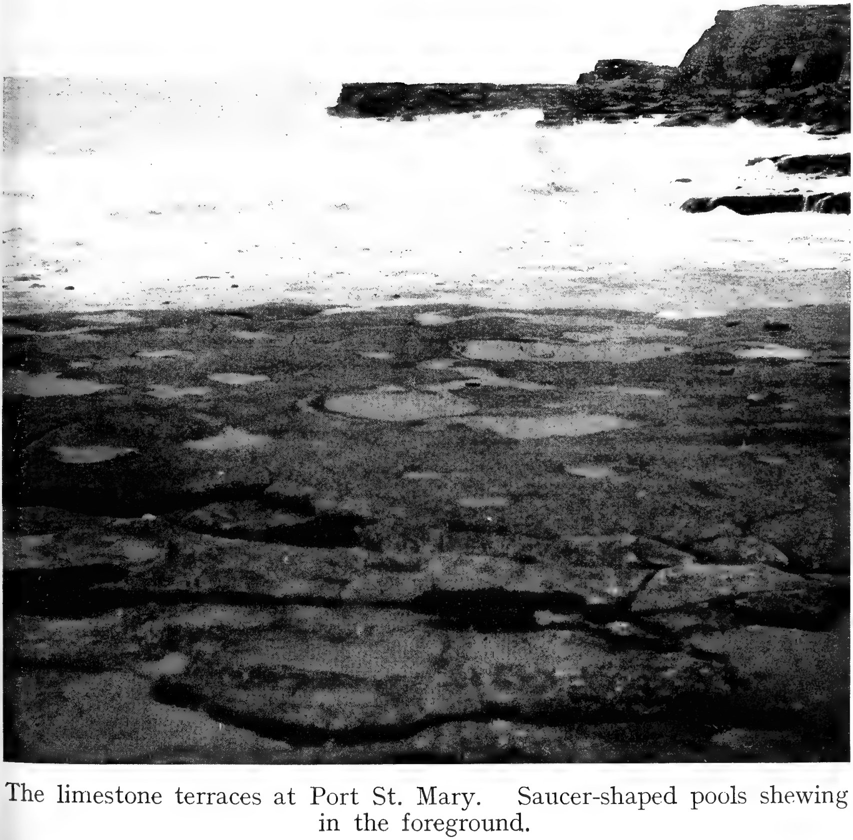
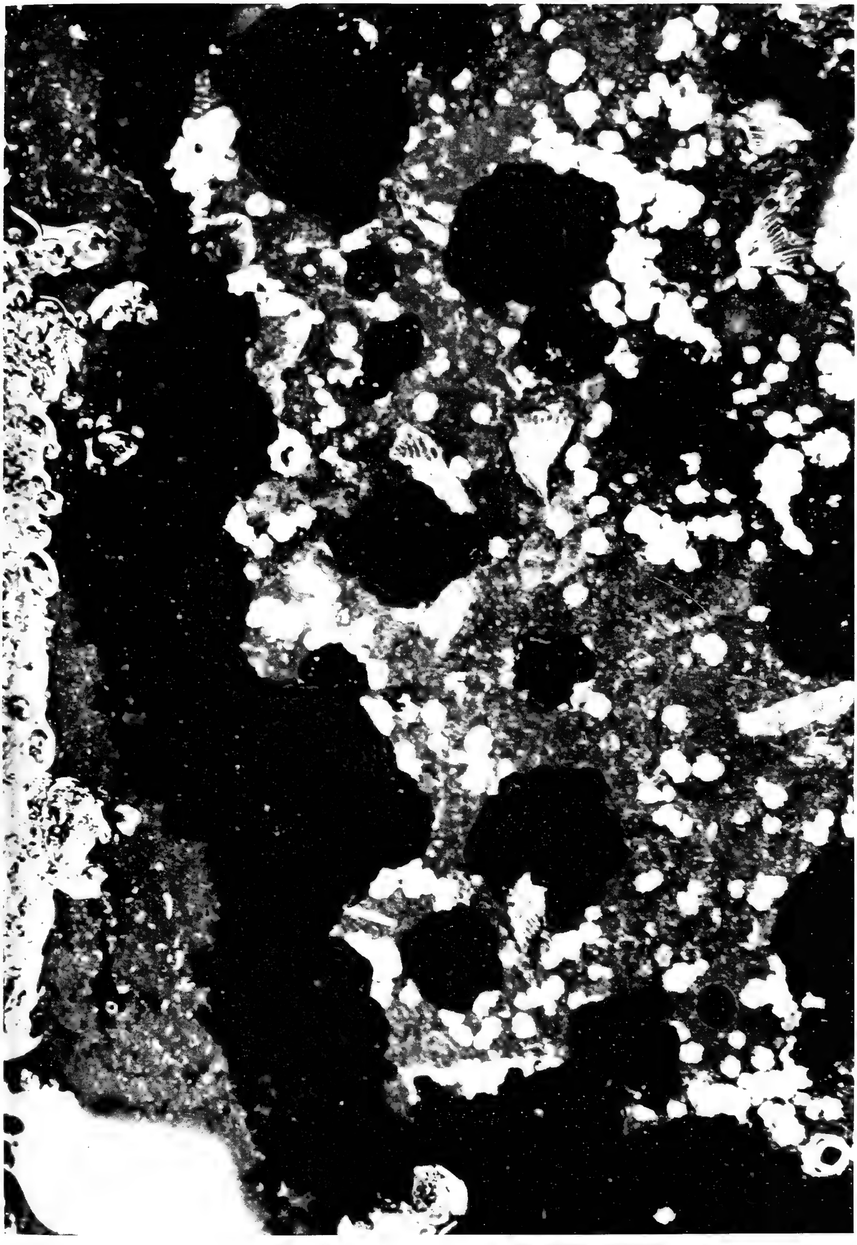


The limestone terraces at Port St. Mary. Saucer-shaped pools shewing in the foreground.



The Ledges, Port St. Mary. Pools from the upper level of the littoral zone shewing *Ralfsia verrucosa* and *Lithothamnion*.

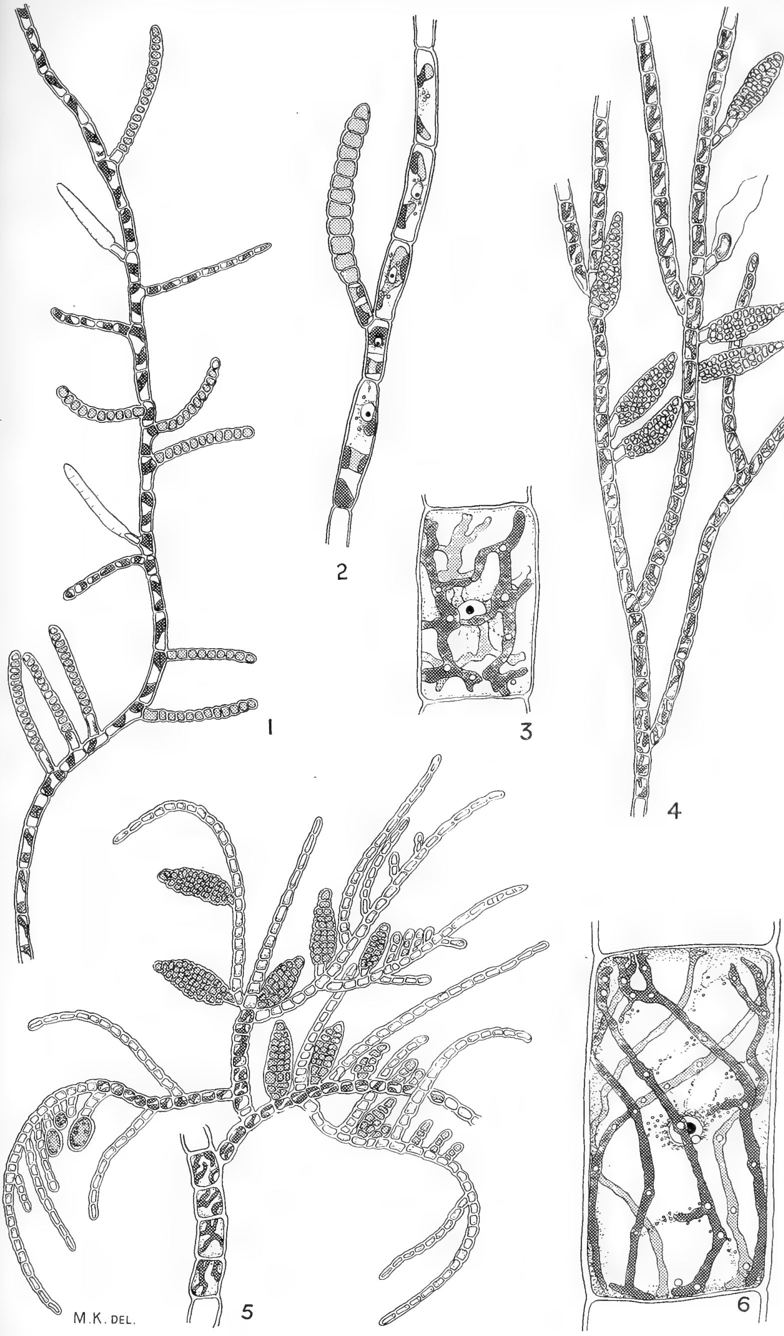
The mid-tide zone of the limestone terraces at Port St. Mary. Inter-pool vegetation with *Laurencia hybrida* dominant.

Low water of spring tides shewing *Laminaria digitata* and *Fucus serratus* association. Pooyllvaaish.

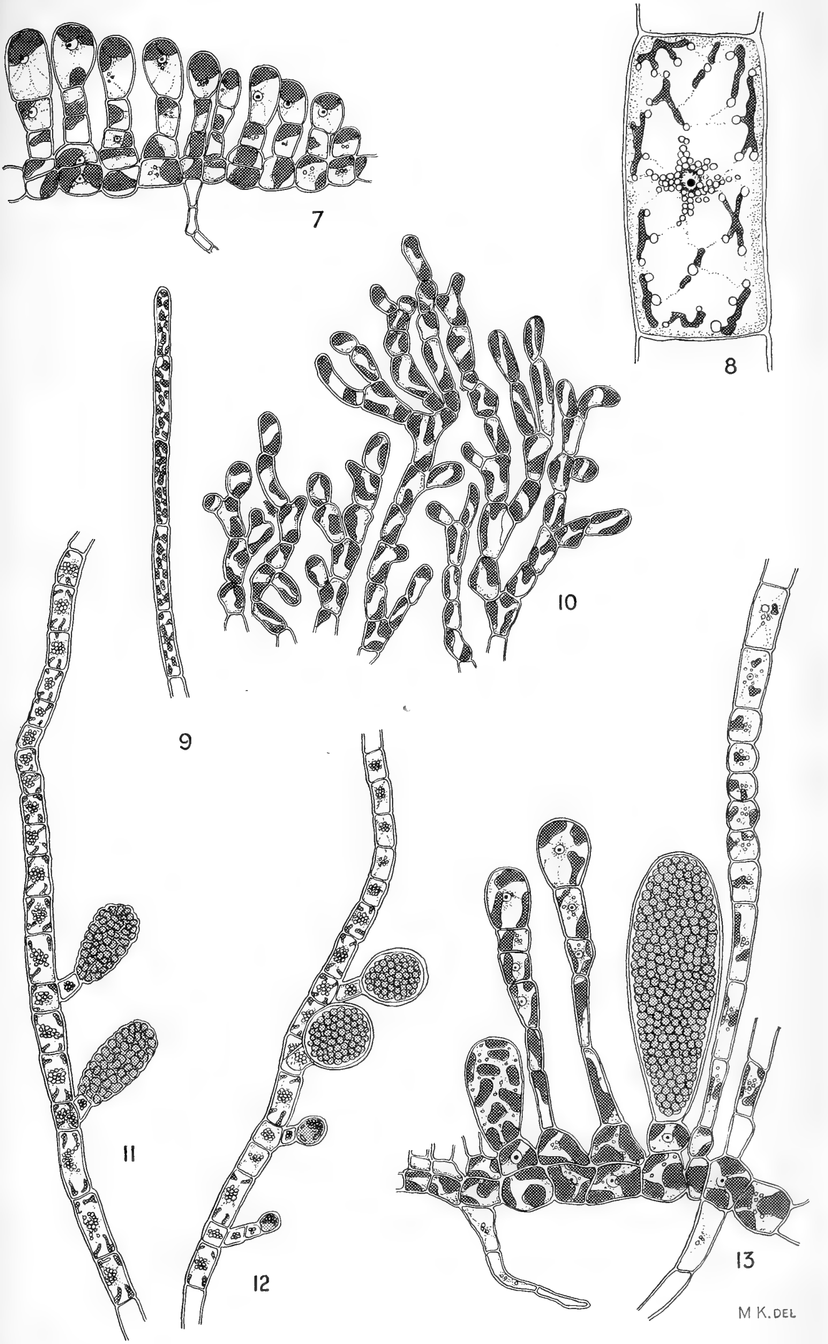
Himanthalia lorea in various stages of development on The Ledges, Port St. Mary.

Photograph of the floor of a pool covered by *Lithophyllum Lenormandi*.
Half natural size.

Small pool on The Ledges, Port St. Mary. Quarter natural size, shewing *Lithophyllum Lenormandi*, *Corallina officinalis* with epiphytes. Limpet with *Ectocarpus* in centre.



1, 2. *Ectocarpus tomentosoides.*
3, 4. *Ectocarpus confervoides.*
5, 6. *Ectocarpus fasciculatus* var. *refracta.*



7, 10, 13. *Ulonema rhizophorum.*
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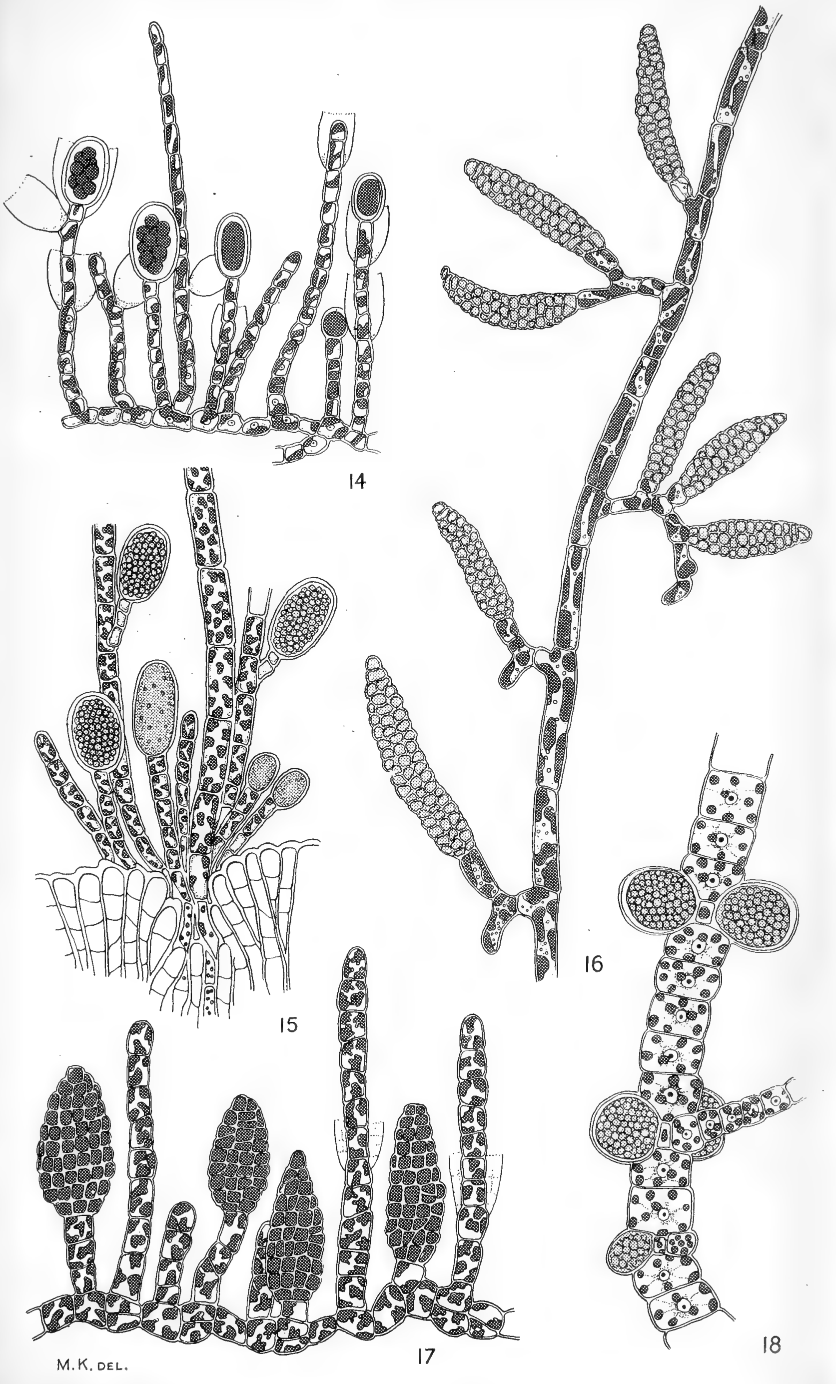
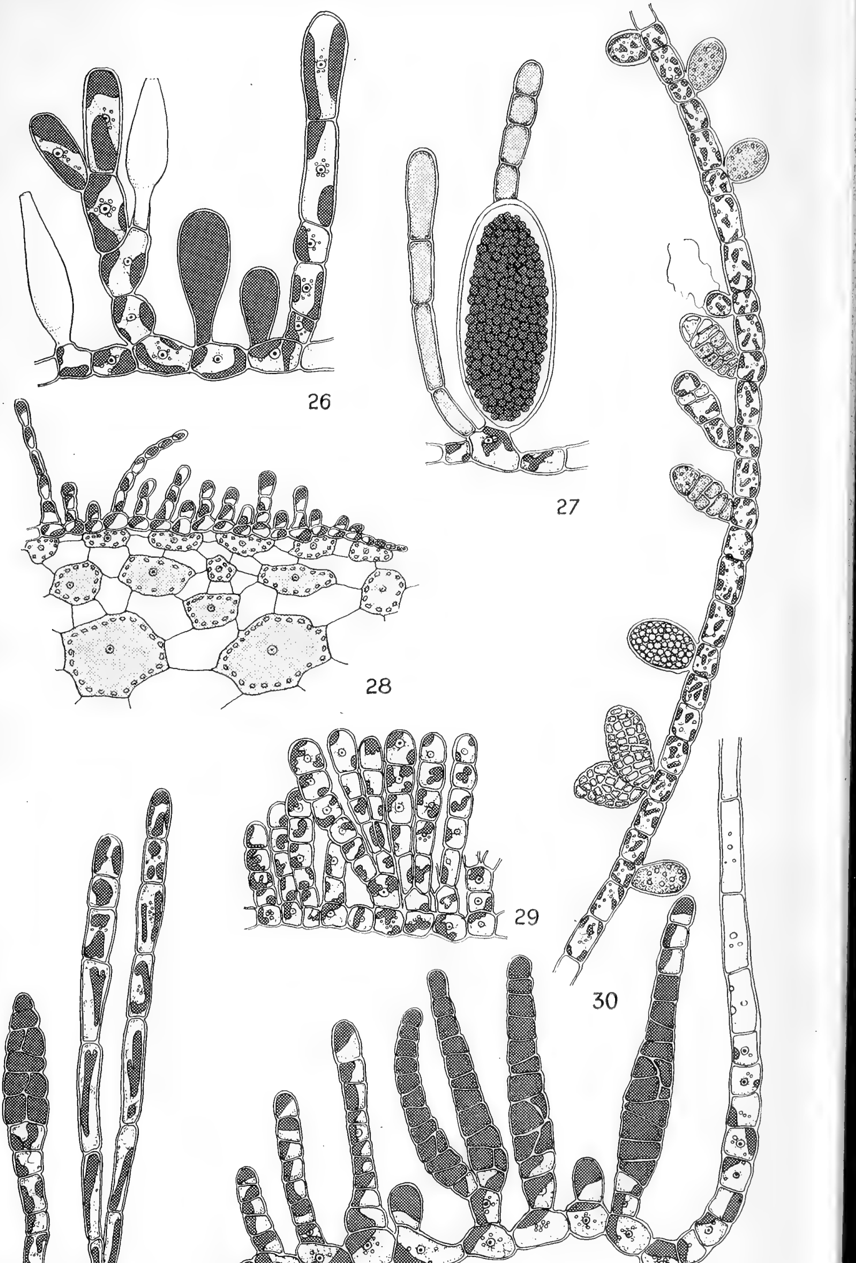
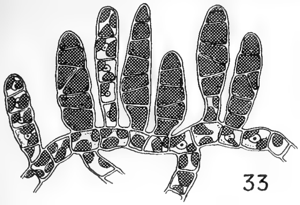


:. *Ectocarpus terminalis.* 16. *Ectocarpus tomentosus.* 18. *Isthmoplea sphaerophora.*
Ectocarpus velutinus. 17. *Hecatonema maculans.*

19, 20, 24. *Ectocarpus luteolus.* 21, 22. *Myriotrichia filiformis.*
23, 25. *Ectocarpus fasciculatus.*



26, 31. *Ascocyclus saccharinae.*
27, 29. *Myrionema saxicola.*
28, 32. *Streblonema Zanardinii.*
30. *Ectocarpus ovatus.*



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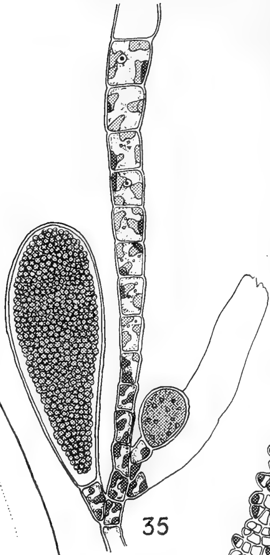

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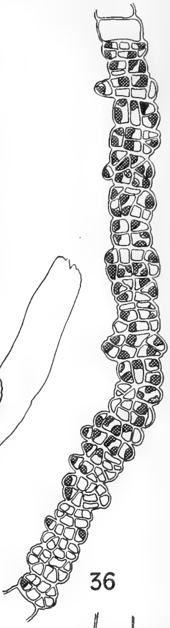

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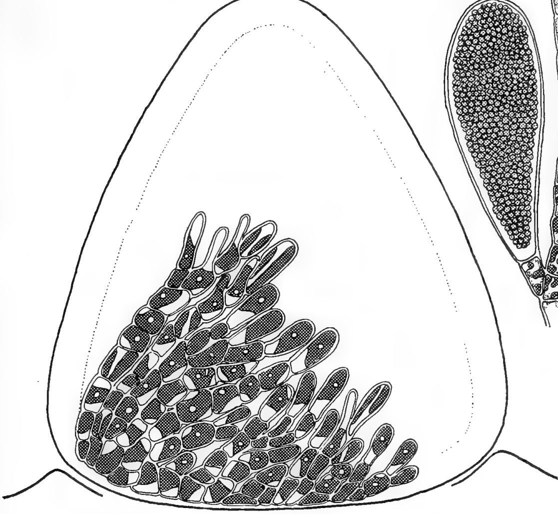

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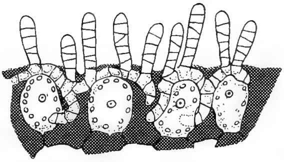

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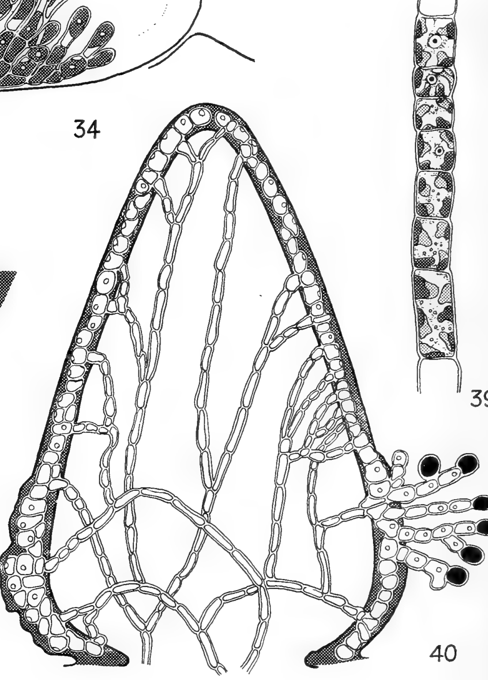

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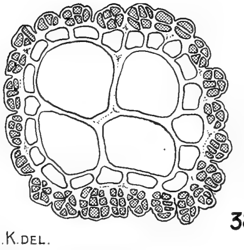

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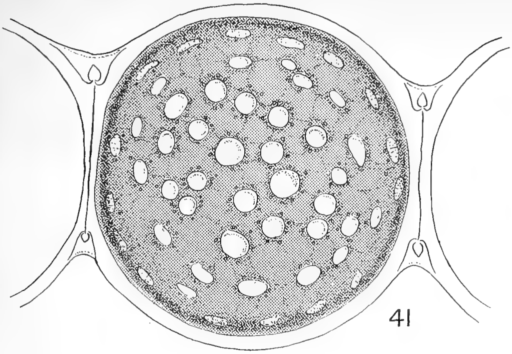
33, 37. *Streblonema parasitica.*
35, 36, 39. *Leptonema fasciculatus.*
38. *Stictyosiphon tortilis.*
34, 40. *Acrochaetium endozoicum.*



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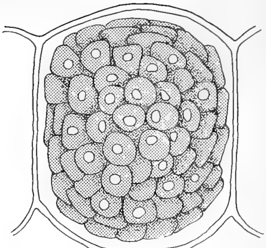

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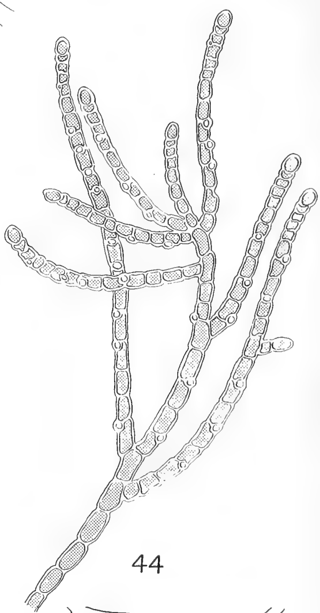

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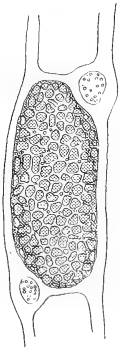

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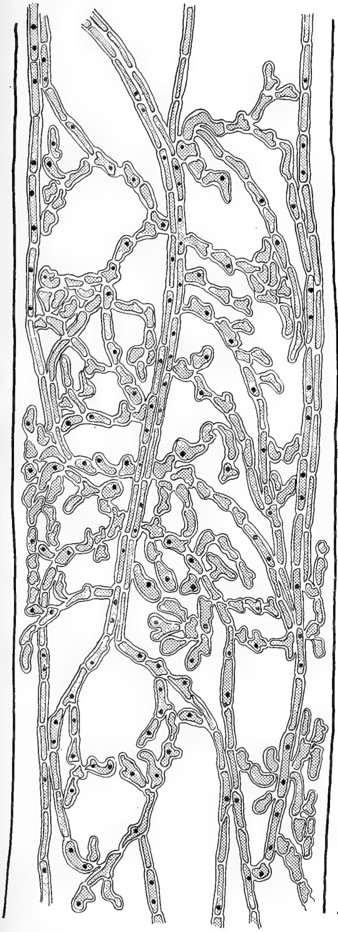

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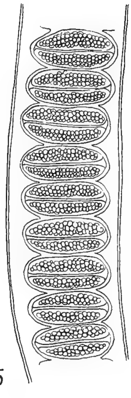

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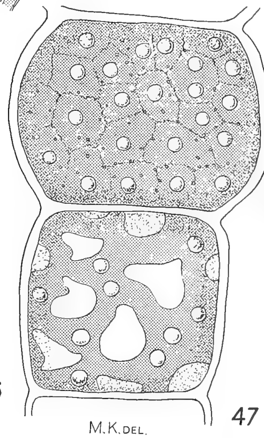

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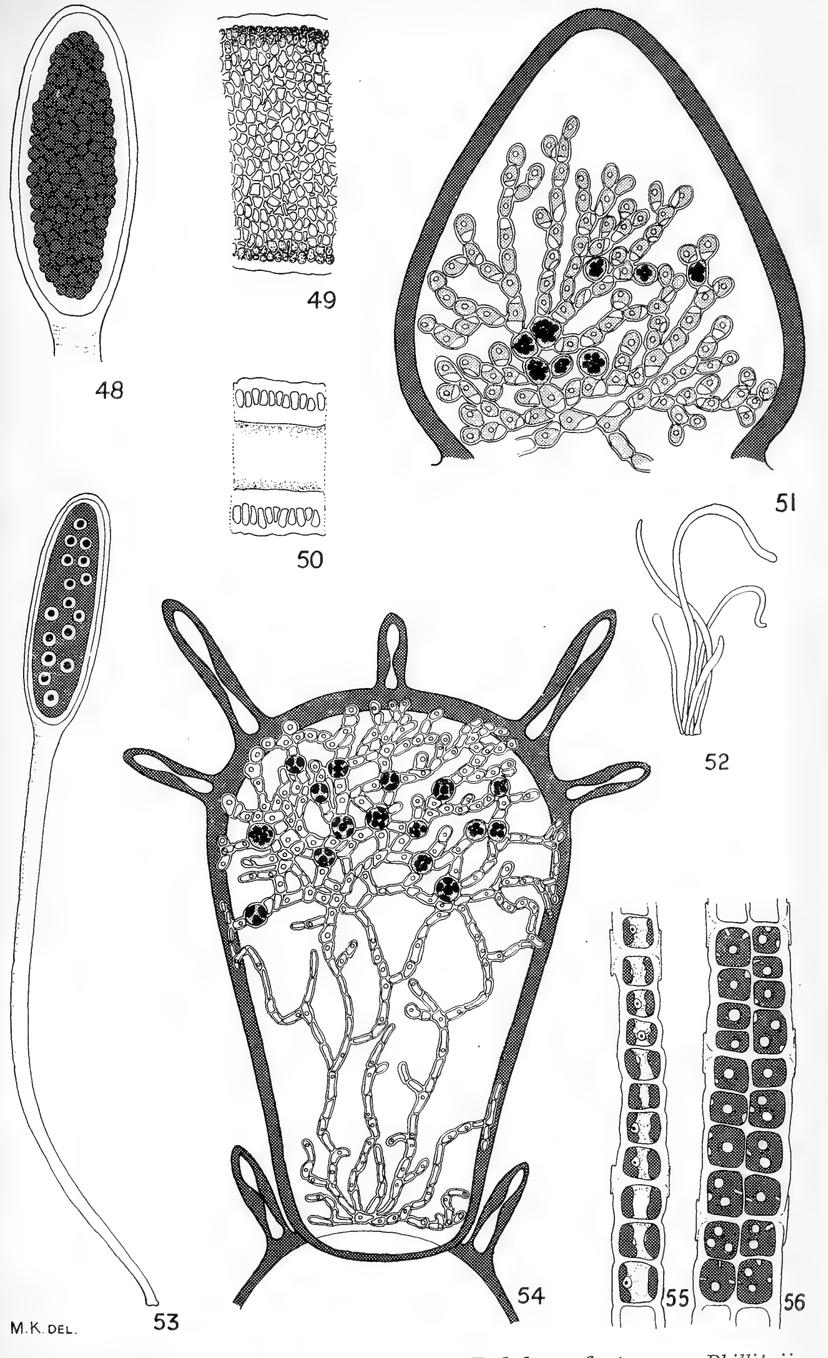
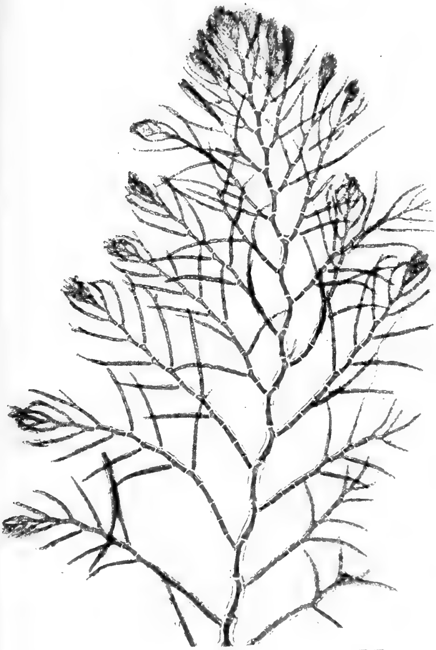
41. *Urospora collabens.*
42, 47. *Urospora mirabilis.*
43, 44. *Trailliella intricata.*
45. *Colaconema reticulata.*
46. *Urospora bangioides.*



48, 53. *Codiolum gregarium.*
59, 50, 52. *Enteromorpha micrococca.*
51. *Endoderma flustrae* var. *Phillipsii.*
54. *Endoderma flustrae.*



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57. *Callithamnion scopulorum.*
58. *Choreocolax Polysiphoniae.*
59. *Prasiola stipitata.*
60. *Callithamnion Dudresnayi.*
61. *Aglaozonia reptans.*

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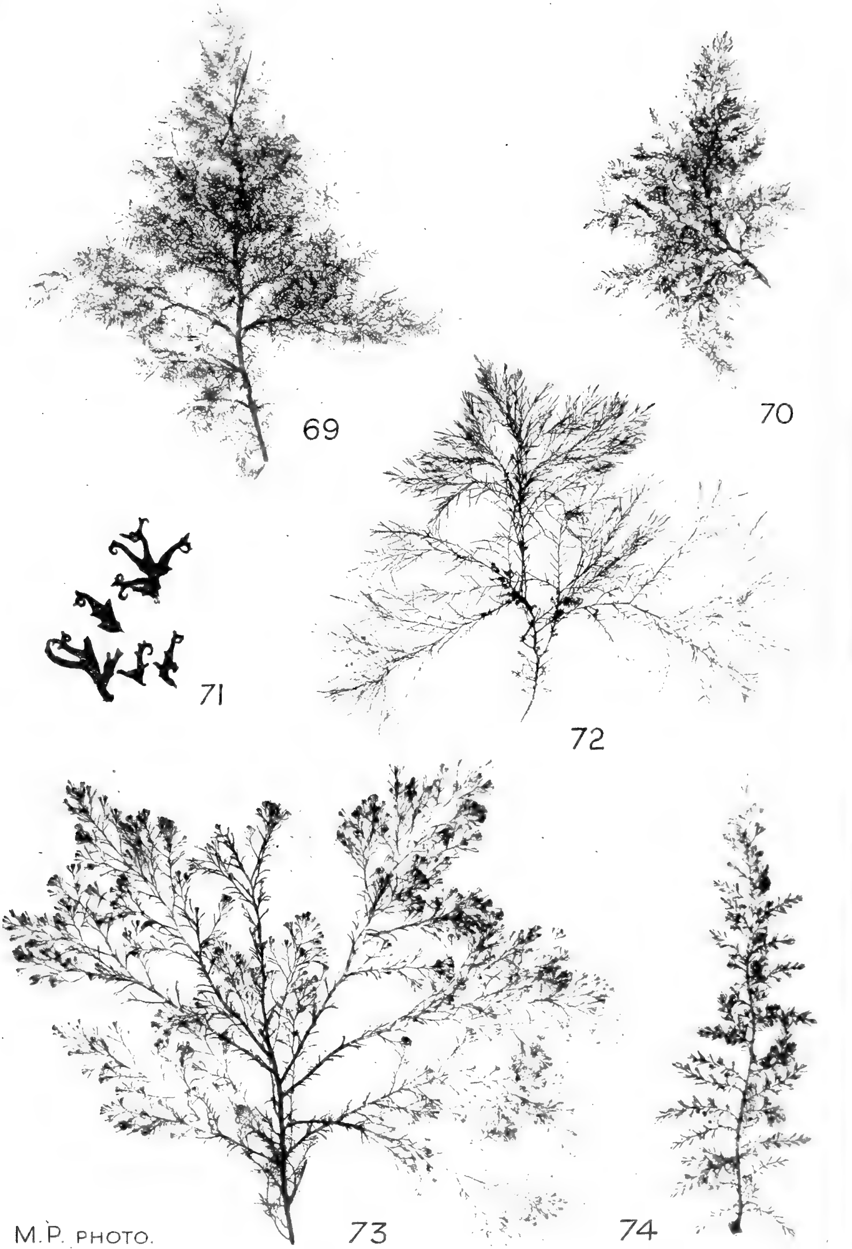
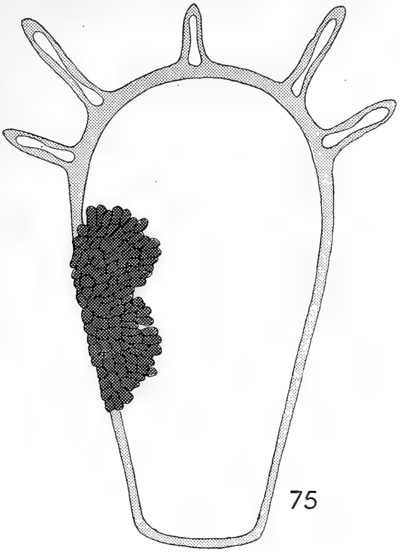
62. *Callithamnion scopulorum.*
63. *Spondylothamnion multifidum.*
64. *Callithamnion polyspermum.*
65. *Callithamnion Dudresnayi.*
66. *Antithamnion cruciatum*
67. Intergrade between *C. Hookeri* and *C. polyspermum.*
68. *Callithamnion arbuscula.*



69, 70. Intergrades between *Callithamnion Hookeri* and *C. polyspermum*.
71. *Nitophyllum uncinatum*.
72. *Pleonosporium Borreri*.
73. *Callithamnion corymbosum*.
74. *Callithamnion brachiatum*.



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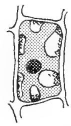

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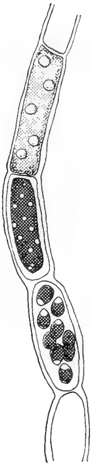

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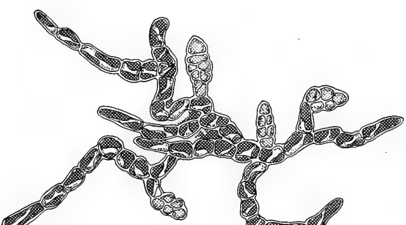

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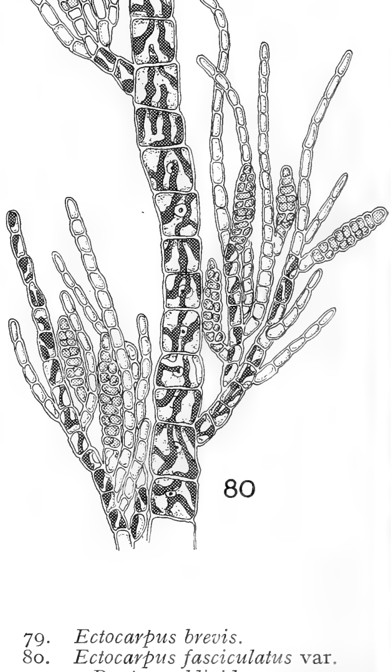

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75, 76. *Erythropeltis discigera.*
77. *Rhizoclonium Kerneri.*
78. *Streblonema infestians.*
79. *Ectocarpus brevis.*
80. *Ectocarpus fasciculatus* var. *Draparnaldioides.*